Identification of Larval Stages of *Caligus clemensi* and *Lepeophtheirus salmonis* From the Broughton Archipelago

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ABSTRACT

Galbraith, M. 2004. Identification of larval stages of *Caligus clemensi* and *Lepeophtheirus salmonis* from the Broughton Archipelago. Can. Tech. Rep. Fish. Aquat. Sci. 2548: 21 p.

Identification of larval stages of Caligid copepods is a difficult task due the small size of the animals, the numerous life stages and the tendency of different species to look analogous until near adult. Most workers in the field are able to identify, by eye, the adult and some of the sub-adult of different species but other stages: nauplii, copepodid, and chalimus; require expert help. It is the hope of this technical report to act as an aide in facilitating identification of all larval stages of *Caligus clemensi* and *Lepeophtheirus salmonis* from local waters.

Contained in this technical report is the description of laboratory techniques for the locating, measuring and identification of attached stages of Caligids on salmonid fry. Due to the limitations of the technical reports graphic abilities the colour pictures are on a CD and referred, in text, by picture name.

RÉSUMÉ

Galbraith, M. 2004. Identification of larval stages of *Caligus clemensi* and *Lepeophtheirus salmonis* from the Broughton Archipelago. Can. Tech. Rep. Fish. Aquat. Sci. 2548: 21 p.

L'identification des étapes larvaires des copépodes de Caligid est une tâche difficile due à la petite taille des animaux, des nombreuses étapes, de développement, et de la tendance des différentes espèces à se ressembler de sembler analogue jusqu'à ce que près de l' âge d'adulte. La plupart des travailleurs dans le domaine peuvent identifier, à l'oeil, l'adulte et certaines des étapes pré-adulte mais d'autres étapes: le nauplius, le copepodid, et le chalimus; exigent l'aide d'expert. Le but de ce rapport technique est de faciliter l'identification de toutes les étapes larvaires de *Caligus clemensi* et de *Lepeophtheirus salmonis* des eaux locales.

Contenue dans ce rapport technique est la description des techniques de laboratoire pour localiser, visualiser, mesurer et l'identification les espèces ainsi que les étapes développement de Caligids sur l'alevin du saumon. En raison des limites du potentiel graphique des rapports techniques, les images en couleur sont sur un CD et référé, sont dans le texte, par le nom d'image.

INTRODUCTION

The co-occurrence of *Lepeophtheirus salmonis* and *Caligus clemensi* on salmonid smolts from the Broughton Archipelago has prompted the awareness for a good manual/key for the identification of attached larval stages of both species. The life cycle for L. salmonis consists of five phases: two free swimming naupliar stages, one free swimming and one attached copepodid (no moult), 4 attached chalimus stages, two mobile sub-adult stages and one mobile adult stage. For C. clemensi it is the same except there appears to be one sub adult stage. Each stage is described in text with drawings and pictures to supplement and aid in the comprehension of key features for that stage. The morphology of the two species is sufficiently different from one another that once the key features are understood, identification is swift. Other *Lepeophtheirus* species from the Pacific northeast are not known to be infective on salmonids preferentially. *L. cuneifer* has been found on rainbow trout and Atlantic salmon cultured in sea pens in the Strait of Georgia (Johnson and Albright 1991). There is some information on identifying the sub adult and adult stages but there are no descriptions of larval stages. *C. clemensi* is the only Caligus found here that will infect salmonids (around 200 known hosts) so the chances of an encounter with another Caligus species on salmon fry should be almost non-existent. *C. macarovi* has been found on the west coast but it is limited to one host: Cololabis saira.

The most difficult stages to differentiate between species are the nauplius, copepodid and first two chalimus stages. They have the similar shapes and body measurements plus their small size makes counting appendages difficult. The Ch3 and 4, the sub adults and adults are fairly easy to distinguish to species; the difficulty is in the determination of life stage of the animal. There is the newly moulted form (young) for each stage plus the middle form and the late form (old) or pre-moult for the next stage. Each of these forms, within a stage, is a different length and width. Care must be taken to confirm that the attributes for each stage has been achieved. In many Ch3's and 4's, the next stage can often be viewed through the exoskeleton.

METHODS

The salmon fry, for this study, were originally bagged and frozen in the field, later transferred to 10% formalin in seawater in opaque plastic jars in the lab. This process may have knocked off some of the mobile stages and the newly attached copepodids. For analysis each fry was removed individually from the jar, placed on a 230μ sieve and gently washed to remove the formalin. The preservative was poured though the sieve to capture any lice that may have been knocked off in handling or transit. All preservative was captured for sample reconstitution after analysis. After washing, the fry were removed to a water filled petrie dish with 1mm grid etched on the bottom. A WILD M420 dissecting scope illuminated both from above and below, with a zoom lens, was used for most of the microscope work. Ocular lenses were 20x with a micrometer and the zoom ranged from 6.3 to 32x. See CD folders: chum and pink, for photos of various stages in situ.

As each Caligid was encountered, the location and amount of damage was noted then they were carefully removed by gripping the tether close to the salmon's body with a pair

of fine forceps and pulling. Attached stages on the body could often be located by the small patch of discolouration or grazing marks around the filament. Attached chalimus on the fins were located by gripping the fry near the front of the head with the fish lying on its belly and gently fanning the fins out with a pair of forceps or stout needle probe. This procedure was repeated with the fry lying on its back. The technique helps the copepod to float out on its tether to be spotted directly or by the shadow it cast. The removed animal was placed in a petrie dish and the total length, minus the tether, was measured to the nearest 0.1mm, stage, sex if possible and species was then determined.

It was sometimes necessary to view the copepods under higher magnification to see key features for species determination. The compound scope used was a Leitz Dialux 22 with 20x oculars, objective lenses to 100x and a 2x multiplier between the objectives and oculars. The copepods were placed on a depression slide, in filtered seawater, face up, so all appendages could be viewed. This method allows for a quick view of the animals without crushing them plus it is not permanent, the animals can be removed from the slide and placed in a labelled vial after identification is made. The depression slide allows the animal to be rolled from side to side by manipulating the cover slip to allow the best view of the appendages. Both the compound and dissecting microscopes have viewing tubes for attachment of a digital camera. The camera used for all photos was a Nikon Cool Pix 4500. The compound scope also has a camera lucida viewing port which was used to make accurate drawings of minute structures.

All specimens examined had been preserved for some time so there was no chance to observe the natural colouration patterns. If the material is fresh, identification of species can be aided by observing pigment, placement and colour. Thomas Schram 1993 describes the pigmentation patterns of *L. salmonis* for all larval stages. His 2004 paper has pigmentation descriptions for other *Lepeophtheirus* nauplii and copepodid stages.

Freezing samples, although quick and easy, does not fix or preserve the sample. Samples need to be attended to quickly to prevent spoilage. Slow freezing causes large crystals to form within muscle tissue, disrupting membranes and cracking carapaces. Care and attention when thawing is very important, as with all fresh seafood, things start to deteriorate quickly when left at room temperature too long. Fixing the samples as soon as they are thawed is imperative.

Alcohol, as a preservative, causes specimens to shrink and bleach out. A drop of glycerine in 70% isopropanol will help keep the animals flexible. If formaldehyde is to be used then a 5 to 10% buffered formalin in water works well. Shrinkage is minimal and the buffer makes the solution neutral. Formalin will cause colour loss but the effect is slower than alcohol. Another side effect of using formalin is that it brings out the parr marks on Chum fry.

The type of preservative and method of preservation all have an effect on the size of the animal and overall condition. This needs to be taken into account when comparing measurements to literature results.

TERMS AND ABBREVIATIONS

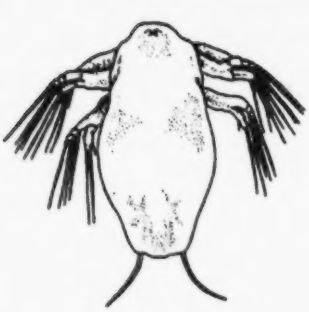
Antennae one and two	=	A1 and A2
Frontal sac	=	FS
Rostrum	=	R
Mouth cone	=	MC
Mandible	=	Mnd
Maxilla one and two	=	Max 1 and Max 2
Maxilliped	=	Mxp
Sternal furca	=	SF
Genital segment	=	GS
Perepods (thoracic limbs)	=	P1, P2, P3, P4, P5, P6
Caudal rami	=	CR
Endopod	=	En
Exopod	=	Ex
Basipod	=	B
Chalimus	=	Ch

See CD for diagrams and photos of above mentioned terms.

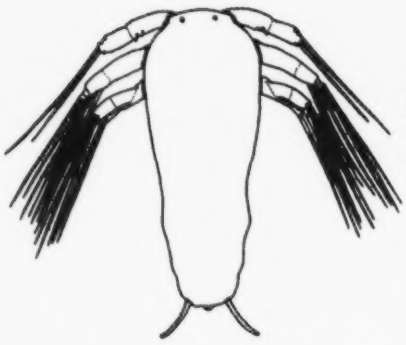
RESULTS

Nauplius and Copepodid

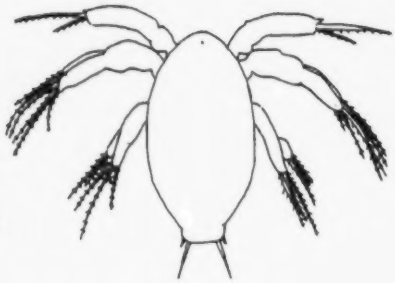
The free swimming stages of both *Lepeophtheirus salmonis* and *Caligus clemensi* comprise of three distinct forms: nauplius I, nauplius II and copepodid. There is a moult between nauplius I, II and copepodid but not between the free swimming and attached copepodid. The naupliar stages of both species look similar in some aspects: one body division, three pairs of swimming appendages anteriorly (antennae 1, antennae 2 and mandible) and a pair of diverging balancers posteriorly. In *L. salmonis*, the body is elongate, wider at the front with a pair of eyespots on the dorsal surface. In C. clemensi, the body is more ovate, wider in the middle and the eyespots are closer together looking like one. Size is also a factor. L. salmonis first nauplius ranges from 0.5-0.58mm; second nauplius is 0.55-0.57mm (Johnson and Albright 1991) whereas C. clemensi is a bit smaller, 0.43-0.50mm and 0.49-0.58mm (Kabata 1972) for first and second nauplius respectively. The second stage nauplius will often have the outline of copepodid visible through the exoskeleton. Nauplii of Caligids have no mouth, the mandible palp is biramous but there is no tooth, no cutting blade. Also they do not have caudal furca. These two characteristics (combined with distinctive shape) make them easy to distinguish from other copepod nauplii. They can be confused with Euphausiid nauplii which have the same number of swimming appendages, no mouth and two setae on the posterior. The differences are that Euphausiid nauplii are more circular in outline with a single eyespot and the posterior appendages are setae which are short and spine-like not long fleshy appendages. In some cases, depending on collection methods, the stabilizers have been knocked off.



C. clemensi nauplius
From Kabata 1972



L. salmonis nauplius
Johnson and Albright 1991



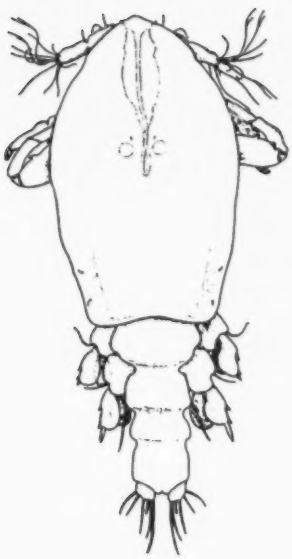
Euphausiid nauplius
Suh et al 1993

The free swimming copepodid is made up of two body parts: the non-segmented ovate prosome and the four segmented urosome with caudal furca. The urosome is actually a combined thorax and pseudoabdomen. The first pair of swimming legs, P1, is on second thoracic segment which is part of the prosome and the second pair, P2, on the first segment of the urosome which is actually the third thoracic segment. The second segment which is the fourth thoracic segment carries spines which represent the reduced third leg, P3. The third segment (fifth thoracic) carries no appendages and the last segment is the undifferentiated genital complex. Off this last segment are the caudal rami, on either side of the anal opening. For simplicity, the terms used will be prosome, the rounded shield like body part carrying the mouthparts and first pair of legs; and urosome, the narrow segmented posterior portion with second pair of legs (and onwards), genital complex and CR.

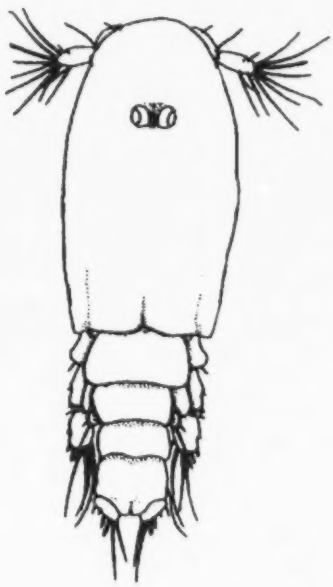
At this stage, the A1 is a sensory appendage and A2 is modified into a prehensile grasping appendage. The mouth cone has developed with the mandible as a cutting device and the maxilla 2 as a scrapper. The maxilla 1 is a tooth-like hook for holding. The maxilliped is made of two indistinctly segmented pieces: the palm (corpus) and the claw (subchela); also prehensile. There are two pairs of swimming legs, each pair bearing an endopod and exopod. The CR is armed with both long and short pinnate setae. The attached copepodid has all the free swimming attributes except that it is usually attached by a tether to its host and is slightly longer. *L. salmonis* copepodid has a single pointed rostrum which is still present in the attached form. The rostrum of *C. clemensi* is small and indeterminate according to Kabata 1972. In the present study, both the free swimming and attached copepodid did not sport any modification that could be labelled a rostrum therefore it considered to be absent. The A2 of *L. salmonis* are very robust in comparison with *C. clemensi*. The maxillipeds of *C. clemensi* are noticeably longer than *L. salmonis* and do not have a three pronged barb mid way along the claw but does have two hooked spines on both the claw and palm. The branching barb of L. salmonis is somewhat variable in number of fingers but in this study the average was three.

C. clemensi has sternal furca behind the Mxp and in front of the P1, *L. salmonis* does not. Viewing *C. clemensi* in profile a pair of hooks is visible, using a dissecting scope, between the Mxp and P1. They appear to be part of the body wall, somewhat blunt in the free swimming form to very hook-like in the attached form. *L. salmonis* does not have these tummy hooks. The frontal filament is developed and visible through the carapace of the free swimming copepodid of *C. clemensi* whereas *L. salmonis* does not show any development until the copepodid has been attached to the host and moulted to Ch1. This makes the copepodid of *L. salmonis* easier to knock off because it usually attached only by the A2 and Mxp. They are often found in the preservative of the sample jar, not on the salmon fry.

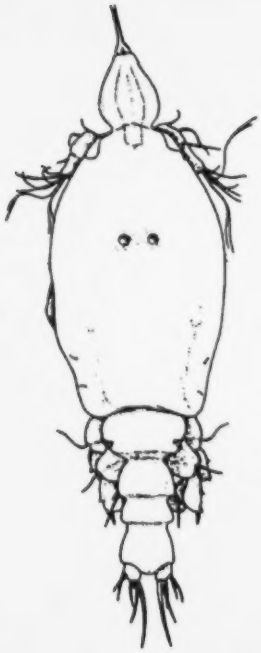
The A1 of *C. clemensi* has a hook or tine near its base and there are several scattered on the oral surface to aid in adhering to the host. Tines are present at the base of the Max1 and 2 in both species.



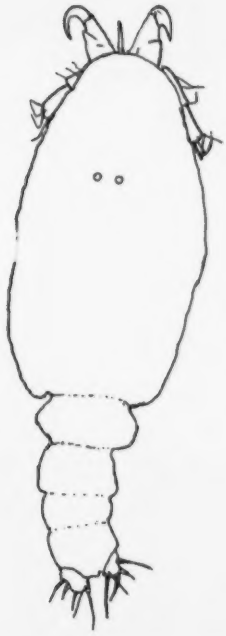
Caligus clemensi copepodid
From Kabata 1972



Lepeophtheirus salmonis copepodid
Johnson and Albright 1991



Caligus clemensi copepodid
attached
From Kabata 1972



Lepeophtheirus salmonis copepodid
attached
present study

The P1, 2, 3 of the free swimming and attached copepodids of both species are very similar in appearance and number of setae. The inner edge of the basis of P2 of *L. salmonis* has a knob like process and *C. clemensi* does not. The best characteristics for quickly differentiating between the two are the A2 shape and size; length of the Mxp and armature; presence/absence of a long pointed rostrum, presence/absence of sternal furca, and total body length.

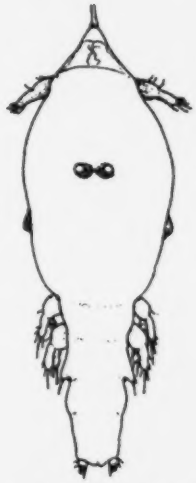
C. clemensi free swimming copepodid ranges is length from 0.64-0.7mm with average being 0.66mm (Kabata 1972). The attached form ranges from 0.7-0.9mm with the average being 0.78mm. *L. salmonis* free swimming copepodid measures 0.69-0.71mm (Johnson and Albright 1991). The attached copepodid is 0.82-1.0mm with the average being 0.88mm. See Table 1 for summary of size ranges and average length for all stages. Measurement is from the front of the shield, excluding tether and frontal sac, to the end of the CR, excluding setae. See Table 2 for summary of features used for identification. See CD folders *L. salmonis* and *C. clemensi* for photos of copepodids in various aspects.

Chalimus 1

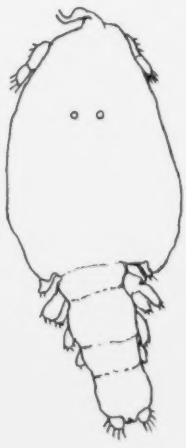
The *C. clemensi* Ch1 is slightly longer than the copepodid stage as the frontal sac is now incorporated into the shield forming a point. *L. salmonis* does not have this feature so the front of the carapace is more rounded. Measurement of chalimus stages and sub adults is from the leading edge of the shield to the end of the CR excluding tether and setae. See

Table 1 for measurements and Table 2 for summary of features. See CD folders salmonis and clemensi for photos of Ch1 in various aspects.

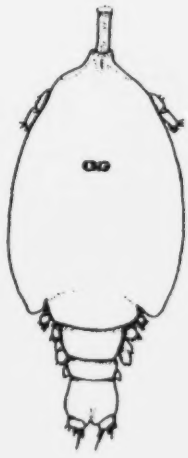
C. clemensi chalimus 1 this study



C. clemensi chalimus 1 Kabata 1972



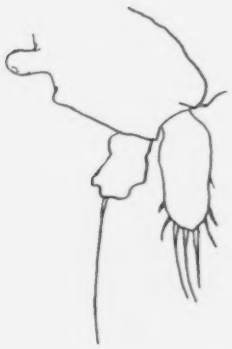
L. salmonis chalimus 1 this study



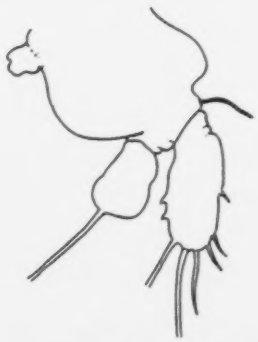
L. salmonis chalimus 1 Johnson & Albright 1991

Most specimens of *C. clemensi* examined showed a darkened area in four spots that is involved with the buccal cone and intestinal tract. *L. salmonis* has a very rounded leading edge and there are no dark spots in the shield. The Ch1 of *C. clemensi* shows an indistinctly segmented urosome whereas *L. salmonis'* urosome segmentation shows clearly. Both exhibit a blurring of segmentation between the prosome and urosome. *C. clemensi* has three legs: P3 small, indistinct with two terminal spines on the exopod and *L. salmonis* has four legs: the P3 with a distinct endo- and exopod and the P4, small

indistinct with two terminal spines. The P1 of C. clemensi has an endopod with one terminal spine and L. salmonis P1 endopod has two spines.

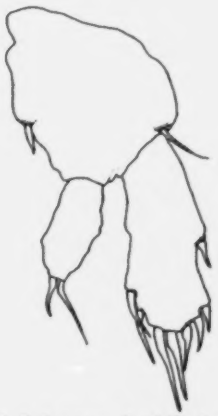


C. clemensi P1 this study
Chalimus 1



C. clemensi P1 Kabata 1972
Chalimus 1

L. salmonis P1 this study
Chalimus 1



L. salmonis P1 Johnson & Albright 1991
Chalimus 1

There is some slight variation in the structure of the P1 from literature description and the present study. The P1 endopod of *C. clemensi* has indentations along its outline and *L. salmonis* has a small knob at the juncture of leg to body with a small spine. Next to the basipod of P2, on the inner side, of *C. clemensi* is a small bump which is not mentioned in literature. Also the leading edge of the prosome with the frontal sac and filament is much more pointed than described or illustrated in literature. There is no discussion, in the literature, of the four dark spots in the middle of the shield which are very evident for all four chalimus stages of *C. clemensi*. It may be a feature that darkens with long exposure to formalin and represents part of the digestive track. See Table 2 for summary of features and CD folders *salmonis* and *clemensi* for photos of chalimus 1 and P1 in various aspects.

The filament attachment and structure is a useful qualitative character that can be used to supplement identification. In *C. clemensi* the filament is simple, hyaline and longer in

proportion to its width than L. salmonis. In *L. salmonis* the filament is broad, cable like multistrand with a gradual attachment area, much shorter and thicker than *C. clemensi*. The distal end of the Mxp subchela in C. clemensi has a small denticle at the tip and a seta part way toward the base whereas L. salmonis has no denticle just the seta.

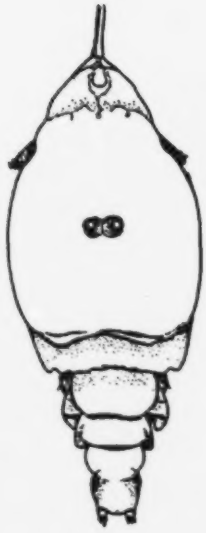
Endopod of P1 *C. clemensi*, different individuals, this study

Chalimus 2

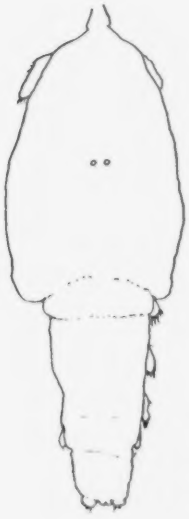
The anterior portion of *C. clemensi* is pointed, especially in comparison with *L. salmonis* which is now developing a more rectangular front. The Ch2 of *C. clemensi* has four legs; the P4 appears as a bent un-segmented sausage with two tiny terminal spines. Contrast that with *L. salmonis* where the P4 is two small segments, the terminal segment has three spines. The urosome of *C. clemensi* is now visibly segmented whereas *L. salmonis* appears to be un-segmented, the reverse of the Ch1 circumstances.

There is a great deal of size variation, per stage, due to the moulting process. Schram 1993 refers to it as early and late chalimus for each stage. In the late chalimus, it is possible to view the next stage through the carapace but the exoskeleton has not been sloughed off. This attribute carries through all stages. It is important to establish whether the chalimus has just moulted, is in the process of moulting or between the two. See Table 2 for key characters for each stage and CD photo files: chum, pink, for pictures depicting various stages of moulting.

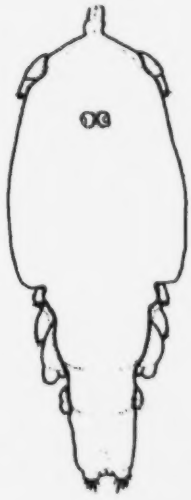
C. clemensi chalimus 2 from study



C. clemensi chalimus 2 Kabata 1972

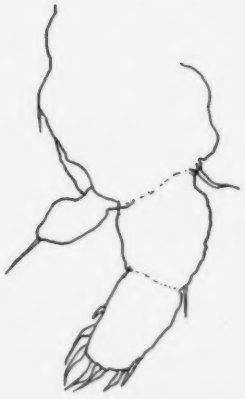


L. salmonis chalimus 2 this study



L. salmonis chalimus 2 Johnson & Albright 1991

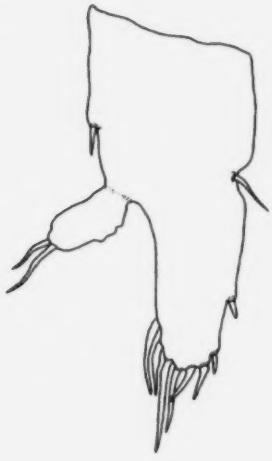
The P1 of both species has the same setation as the Ch1 but the segmentation is less discernable and the endopod is reduced in size. The terminal setae of the endopod are reduced in length. *L. salmonis* still has the knob at the inside edge of the juncture of the leg, a single spine pointing inwards to the centre line of the body but *C. clemensi* has lost its internal knob for both P1 and P2.



C. clemensi P1 from study
Chalimus 2

C. clemensi P1 Kabata 1972
Chalimus 2

L. salmonis P1 from study
Chalimus 2



L. salmonis P1 Johnson & Albright 1991
Chalimus 2

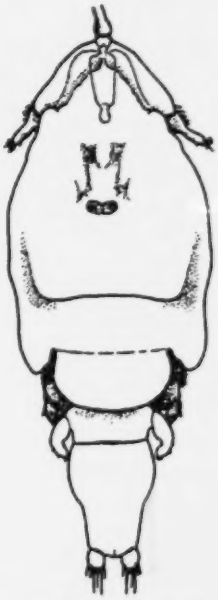
Some *L. salmonis* filaments have developed two blunt points arising from the base where it attaches to the carapace. The purpose of the apparatus is not clear and it does not appear on *C. clemensi*.

Chalimus 3

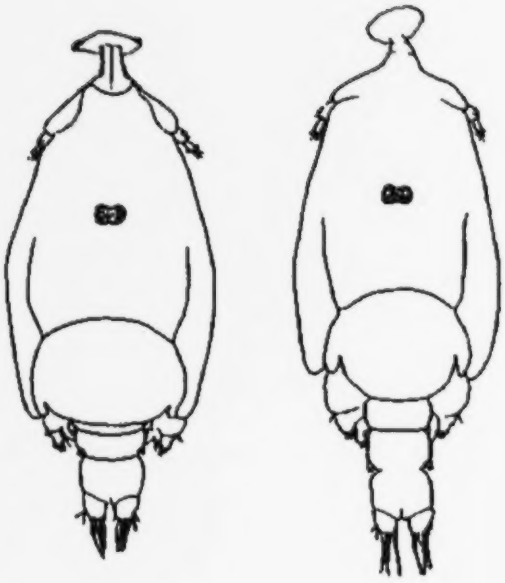
C. clemensi has lunules visible under the leading edge of the carapace, just posterior to the filament making the leading edge is quite pointed in comparison to *L. salmonis*. The lunules are either well defined from the leading edge by a suture or it is possible to see

where the demarcation would be and the lunules show as a cup like formation beneath the carapace. The leading edge of *L. salmonis* is becoming more square-like and no lunules. The segmentation of the urosome is visible for both species as is the development of posterior lobes of the carapace of the prosome. The segmentation between the prosome and the urosome is indistinct for *C. clemensi*, more visible with *L. salmonis*. The suture line between the genital segment and the last urosome segment is indistinct in both *C. clemensi* and *L. salmonis*. The SF is starting to form and is visible, in some specimens, through the exoskeleton when viewed ventrally. It forms a small lump in the exoskeleton just anterior to the P1 at the mid line of the body on the ventral surface. In some it is possible to see the shape of the furca prongs starting to develop. At this stage, sutures in the dorsal surface of the prosome appear. These are not readily visible in preserved material. The P2 and P3 are becoming much larger, expanded and flattened, visible in dorsal view. See Table 2 for key characters for each stage and CD photo files: salmonis and clemensi, for pictures of the various features discussed.

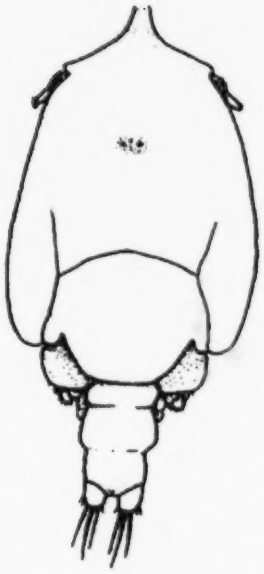
C. clemensi chalimus 3 from study



C. clemensi chalimus 3 Kabata 1972



L. salmonis chalimus 3 Schram 1993
young and old



L. salmonis chalimus 3
Johnson & Albright 1991

The P4 of *C. clemensi* now has 5 spines and the same for *L. salmonis* but *L. salmonis* has also developed the beginnings of P5 represented by 2 spines on the posterior-lateral edge of the genital segment.

The P1 endopod of *C. clemensi* is greatly reduced, just a small knob remains with no setae, the exopod is lengthening and the terminal setae are becoming more distinct. *L. salmonis* P1 endopod is smaller but the 2 terminal setae still present. The exopod has grown longer and faint lines of segmentation are visible. The endopod setae from the present study differ slightly from those described in the literature by being longer.

C. clemensi P1 from study
Chalimus 3

C. clemensi P1 Kabata 1972
Chalimus 3

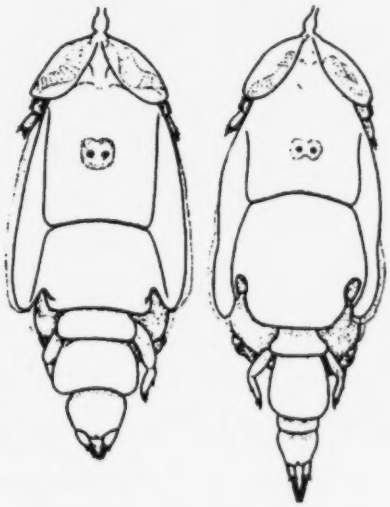
L. salmonis P1 from study
Chalimus 3

L. salmonis P1 Johnson & Albright 1991
Chalimus 3

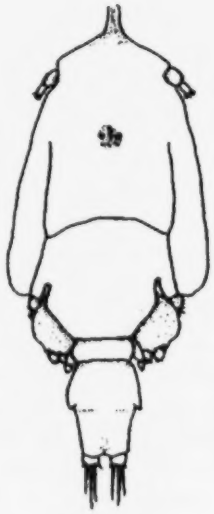
Chalimus 4

The main difference, besides length and sexual dimorphism, between Ch3 and 4 is development of sternal furca prongs, still covered but visible through the exoskeleton. The marginal membrane of the prosome is just starting to develop. Suture marks in the dorsal shield are now easy to discern. The main difference between *C. clemensi* and *L. salmonis* is the presence of lunules at the leading edge of the carapace. The female of *C. clemensi* has 3 urosome segments and the male 4. Also, the male is a little bit longer and narrower than the female. In *L. salmonis* the distinction between sexes is more subtle.

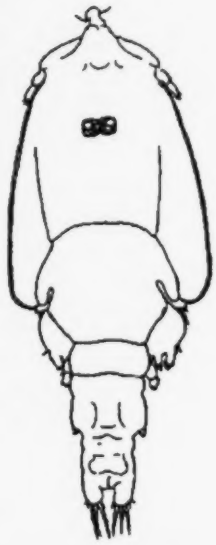
The female has the start of cuticular folds visible through the exoskeleton at the leading edge of the genital segment. The male of *L. salmonis* has the setae of P6 visible through the exoskeleton on the genital segment just posterior to the P5. Comparing the following figures of Ch4, the Schram drawing is of a female with the cuticular folds showing as a squaring on the leading edge of the genital segment. The male Ch4 is the Johnson and Albright drawing. The P1 endopod is now greatly reduced in *L. salmonis* but has disappeared in *C. clemensi*. P1 through P5 of both species are becoming longer and wider with an increase in armature, most noticeable on P2, P3 and P4. A membranous fringe is starting to develop around the edges of the prosome and the H-shaped sutures are much more noticeable. The tether of some L. salmonis has a nub projecting laterally just at the base where it meets the carapace. See Tables 1 and 2 for summary of features and CD folders salmonis and clemensi for photos of Ch4 in various aspects.



C. clemensi Kabata 1972
Chalimus 4 female and male



L. salmonis Chalimus 4
Johnson & Albright 1991

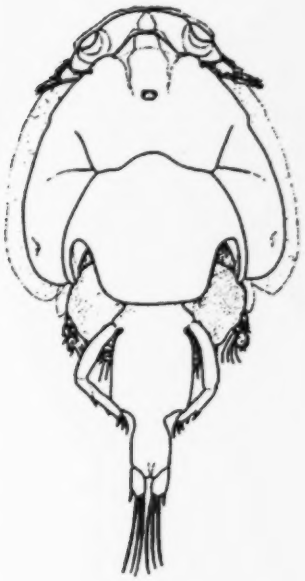


L. salmonis Chalimus 4
Schram 1993

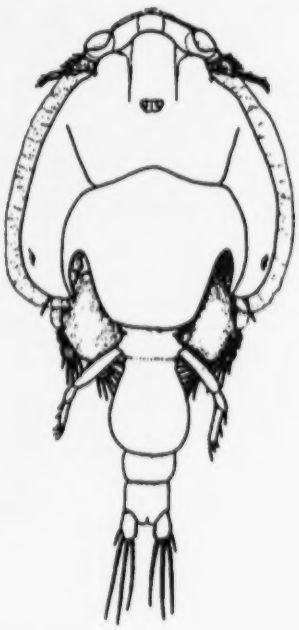
Sub Adult 1 and 2

The sub adult stages of both species look very similar to the adult stages except the genital segment is not developed and the overall measurements are smaller than an adult. Again the *C. clemensi* can be easily differentiated from *L. salmonis* due to the presence of lunules on the leading edge of the carapace. The differences between the sexes are more marked in both species. *C. clemensi* male has 4 urosome segments and the female 3. In *L. salmonis*, the male has a P6 and the female does not. Also, the cuticular folds of the female are very noticeable at the leading edge of the genital segment. These folds look like nubs on either side of the genital segment just behind the P4. The function of the fold

of material may be to allow expansion of the genital segment without having to moult. The main difference between the sub adult stages 1 and 2 is in the overall length and the development of the genital segment. In the female, there is a noticeable elongation of the genital segment with distal projections or squaring of the posterior edge from sub adult 1 to 2. In the male there is elongation combined with a rounding or barrel shape to the genital segment. The sub adult stages, for both species, sport a discernable fringe around the carapace. See Table 2 for summary of characteristic features and CD folders: salmonis and clemensi, for photos of sub adults and adults in various aspects.

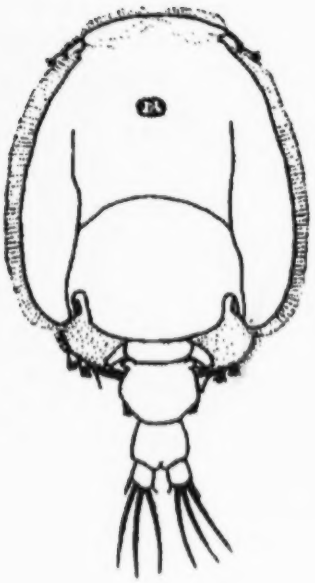


Sub adult female *C. clemensi*
From Kabata 1972

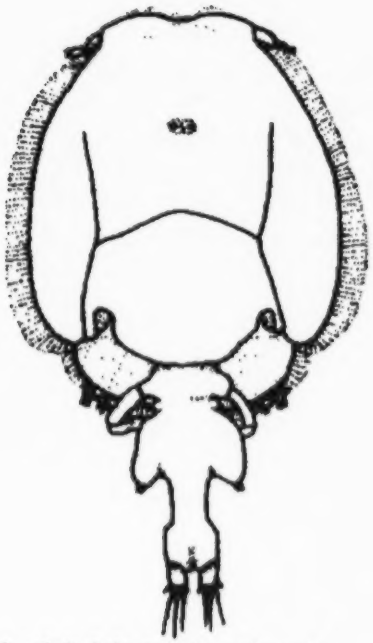


Sub adult male *C. clemensi*

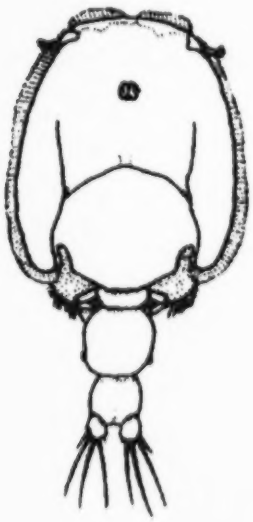
Or immature female and male.



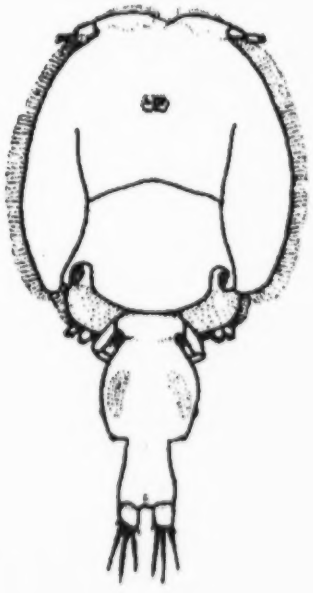
Sub adult 1 female *L. salmonis*
From Johnson and Albright 1991



Sub adult 2 female *L. salmonis*



Sub adult 1 male *L. salmonis*
From Johnson and Albright 1991



Sub adult 2 male *L. salmonis*

C. clemensi sub adult 1 has not been documented in the literature. In the present study, all Ch4 females looked to be moulting and the next stage was visible through the carapace. Some of the Ch4 appeared to be sub adults 1 but the filament was still intact and the sternal furca did not appear to be functional. It is possible that the sub adult 1 is a phase that is skipped or passed through while still attached by the tether and the first mobile stage is the sub adult 2 or that there is no sub adult stage 1 or 2, just an immature adult which grows to an adult size with the development of the reproductive organs. Pisaecki 1996 questions whether there are 2 sub adult stages for *C. clemensi* though Kabata 1972 stated there was but did not document it. Pisaecki described all stages for *C. elongatus* and stated that there was no sub adult stage for this species as there was no moult between the sub adult and adult stages. He based this upon the development of the frontal filament which is changed at each moult for Caligus but not Lepeophtheirus. The young adults were attached by their frontal filament and then broke free, retaining a portion of the filament. The young adult male and female is very similar in overall anatomy to the adults, just smaller with less developed genital complex.

Some quick notes for clarification: Fig 5 C-F on page 14 of Margolis and Kabata 1988 are of appendages taken from Kabata 1972 figures of sub adult male and female *C. clemensi*. Figure 33 on page 4 of Johnson and Kent 1992 depicting the life cycle of sea lice has the free swimming copepodid and ch2 of *C. clemensi* from Kabata 1972 fig 9 and 10 while the other drawings in the figure are of *L. salmonis*.

There is a need to observe and document the life cycle of *L. cuneifer* and *C. clemensi*. The former species to prevent misidentification of *Lepeophtheirus* copepods in light of the information about infestations of cultured salmonids in the Strait of Georgia and the later to determine the absence/presence of sub-adult stages (is there a moult after chalimus 4).

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Table 1

Length in mm of L. salmonis and C. clemensi stages with comparison to other studies and other species

species		attached copepodite	chalimus 1	chalimus 2	chalimus 3	chalimus 4f	chalimus 4m	sub adult 1 f	sub adult 1 m	sub adult 2 f	sub adult 2 m	
Lepeophtheirus	average	0.88	1.25	1.48	2.34	2.79	2.82	3.59	3.59	4.55	4.78	present study
salmonis	range	0.8-1.0	1.1-1.35	1.39-1.6	2.1-2.75	2.52-3.21	2.4-3.1	3.15-3.8	2.92-3.8	4.2-5.2	4.7-4.9	
	n	51	62	69	84	21	27	6	14	6	6	
Caligus	average	0.78	0.95	1.34	2.05	3.26	3.17				4.45	present study
clemensi	range	0.7-0.9	0.8-1.1	1.1-1.6	1.66-2.56	3-3.4	2.8-3.48					
	n	50	136	57	30	9	7				1	
literature												
l. salmonis	range	0.69-0.71*	1.19-1.26	1.46-1.58	2.12-2.28	2.59-2.95	2.59-2.95	3.54-3.86	2.45-3.25	4.89-5.91	3.75-4.77	Johnson/Albright 1991
l. salmonis	range	0.72-0.83	1.02-1.14	1.15-1.44	1.84-2.3	2.04-2.72	2.04-2.72	3.3-3.8	2.7-3.6	4.48-5.97	4.1-4.5	Schram 1993
c. clemensi	range	0.66-0.74*	0.84-1	1.24-1.44	1.8-2	2.76-3.1	2.88-3.4			4.1	4.5	Kabata 1972
other species from literature												
l pectoralis	average	0.85*	1.14	1.38	1.74	1.94	1.94	2.35	2.09	2.9	2.44	Boxshall 1978
	range	0.78-.91	1.03-1.28	1.24-1.46	1.48-1.91	1.74-2.16	1.74-2.16	2.16-2.6	1.86-2.28	2.68-3.26	2.34-2.59	
	n	50	25	10	15	10	10	20	25	20	10	
l hospitalis	average	0.7*	0.97	1.08	1.73	1.83	1.83	2.89	2.44	3.84	2.96	Voth 1972
	n	10	10	10	10	10	10	10	10	10	10	
l dissimulatus	average	0.55*	0.65	0.8	0.9	1.2	1.2	1.55	1.57	1.95	2.1	Lewis 1963
	range	0.48-0.65	0.5-0.7	0.7-1.0	0.8-1.2	1.1-1.3	1.1-1.3	1.42-1.75	1.45-1.75	1.75-2.3	1.9-2.4	
c punctatus	average	0.56*	0.73	1.05	1.64	2.51	2.38			2.96	2.81	Kim 1993
	range	0.55-0.58	0.68-0.78	0.91-1.17	1.48-1.81	2.2-2.78	2.05-2.6			2.71-3.15	2.61-3.07	
c. elongatus	average	0.66*	0.82	1.34	2.34	3.79	3.36			4.93	3.8	Piasecki 1996
	range	0.58-0.81	0.58-1.05	0.91-2.18	1.74-3.97	3.19-4.7	2.69-4.19			4.21-5.39		
	n	308	273	244	261	85	123			39		

* measurements of free swimming copepodite

Table 2
Identification features of attached and mobile larval stages from pink and chum fry 2003

attached by tether — length in mm

	copepodite	chalimus 1	chalimus 2	chalimus 3	chalimus 4f	chalimus 4m
L. Salmonis	0.82-1.0	1.1-1.35	1.39-1.6	2.1-2.75	2.52-3.21	2.4-3.1
	single pointed rostrum	urosome segments distinct	urosome segments indistinct	5 legs	5 legs	6 legs
	3 legs	4 legs	4 legs	p1 end reduced 2 spines	sternal furca	sternal furca
	no sternal furca	p1 end 2 terminal spine	p1 end 2 terminal spines	p4 5 spines	p1 end reduced 2 spines	p1 end reduced 2 spines
	mxp claw 3 tine spine	p4 2 spines	p4 3 spines	p5 2 spines	no p6	p6 visible
	mxp palm smooth	cephalic schield rounded	cephalic schield squarish	cephalic schield squarish	wide	narrow
	A2 robust	tether short thick	tether short thick		cuticular fold visible	no cuticular fold
C. clemensi	0.7-0.9	0.8-1.1	1.1-1.6	1.66-2.56	3-3.4	2.8-3.48
	no rostrum	urosome segments indistinct	urosome segments distinct	4 legs	4 legs	4 legs
	3 legs	3 legs	4 legs	p1 end reduced no spine	sternal furca	sternal furca
	sternal furca	p1 end 1 terminal spine	p1 end 1 terminal spine	p4 5 spines	p1 no endopod	p1 no endopod
	mxp claw 2 spines	cephalic schield pointed	cephalic schield pointed	cephalic schield pointed	lunules forming	lunules forming
	mxp palm 3 spines	tether thin long	tether thin long	lunules visible	3 urosome segments	4 urosome segments
	mxp long					

no tether — length in mm

	sub adult 1 f	sub adult 1 m	sub adult 2 f	sub adult 2 m
L. Salmonis	3.15-3.8	2.92-3.8	4.2-5.2	4.7-4.9
	5 legs	6 legs	5 legs	6 legs
	no p6	p6 2 spines	no p6	p6 3 spines
	genital segment square	genital segment round	genital segment with lobes	genital segment barrel
	cuticular fold	no cuticular fold	cuticular fold	no cuticular fold
C. clemensi			4.1 est	4.5
may have tether			5 legs	6 legs
			no p6	p6 2 spines
			3 urosome segments	4 urosome segments
			lunules	lunules

Sea Lice Larvae of the Broughton Archipelago

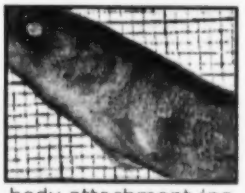
Please select one of the following groups:

- Chum
- Pink
- Clemensi
- Salmonis
- Drawings

Fisheries and Oceans Canada
Pêches et Océans Canada

Chum with Lice

4 way body scrum.jpg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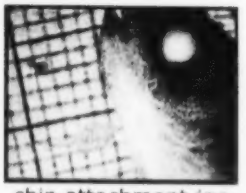

chin attachment.jpg

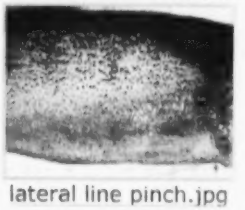
dorsal fin clem ch1.jpg

dorsal fin.jpg

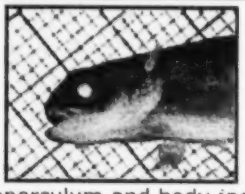
lat line graze mark.jpg

lateral line close up.jpg

lateral line pinch close up.jpg


lateral line pinch.jpg

lateral line.jpg


operculum and body.jpg

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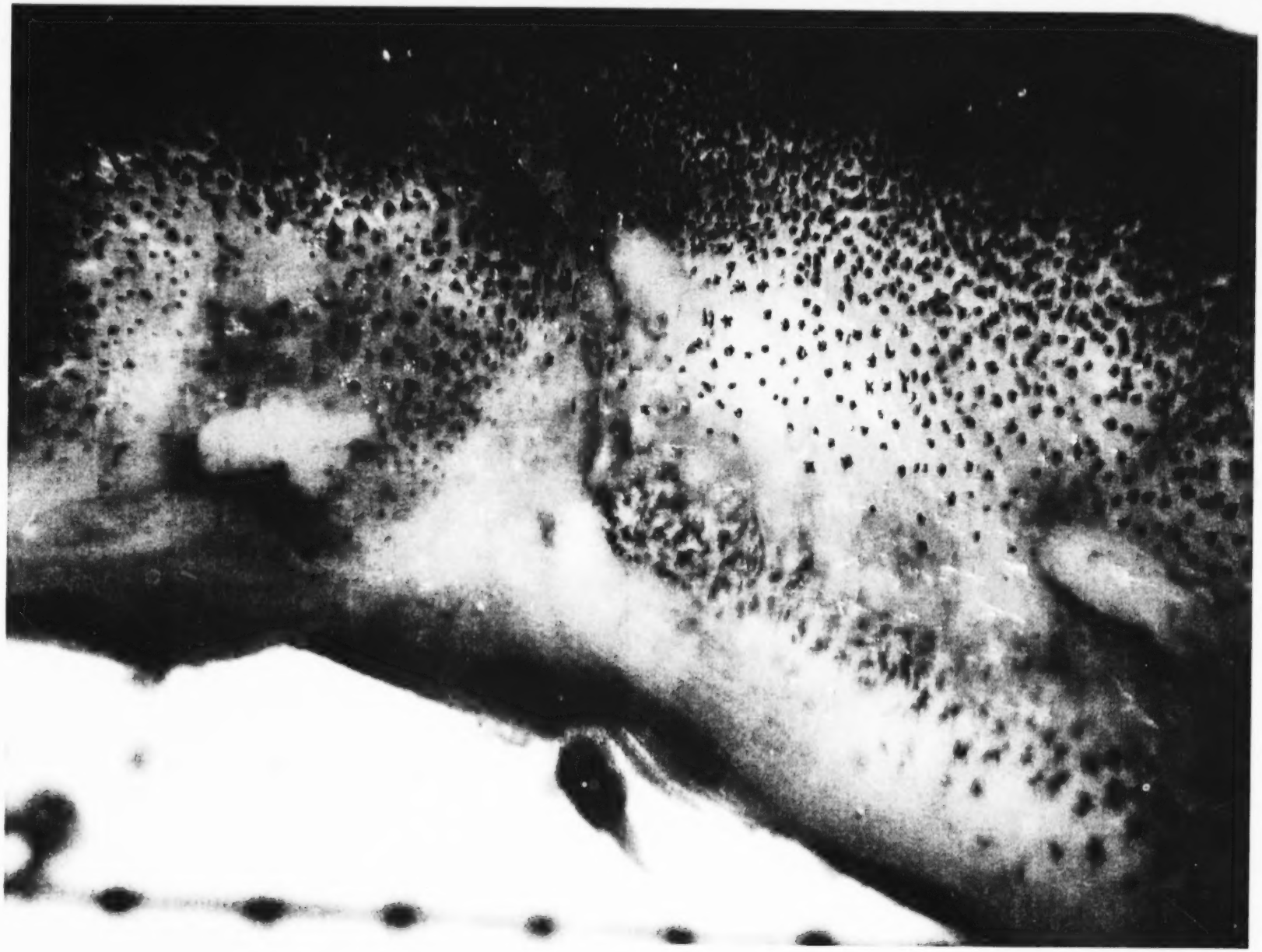
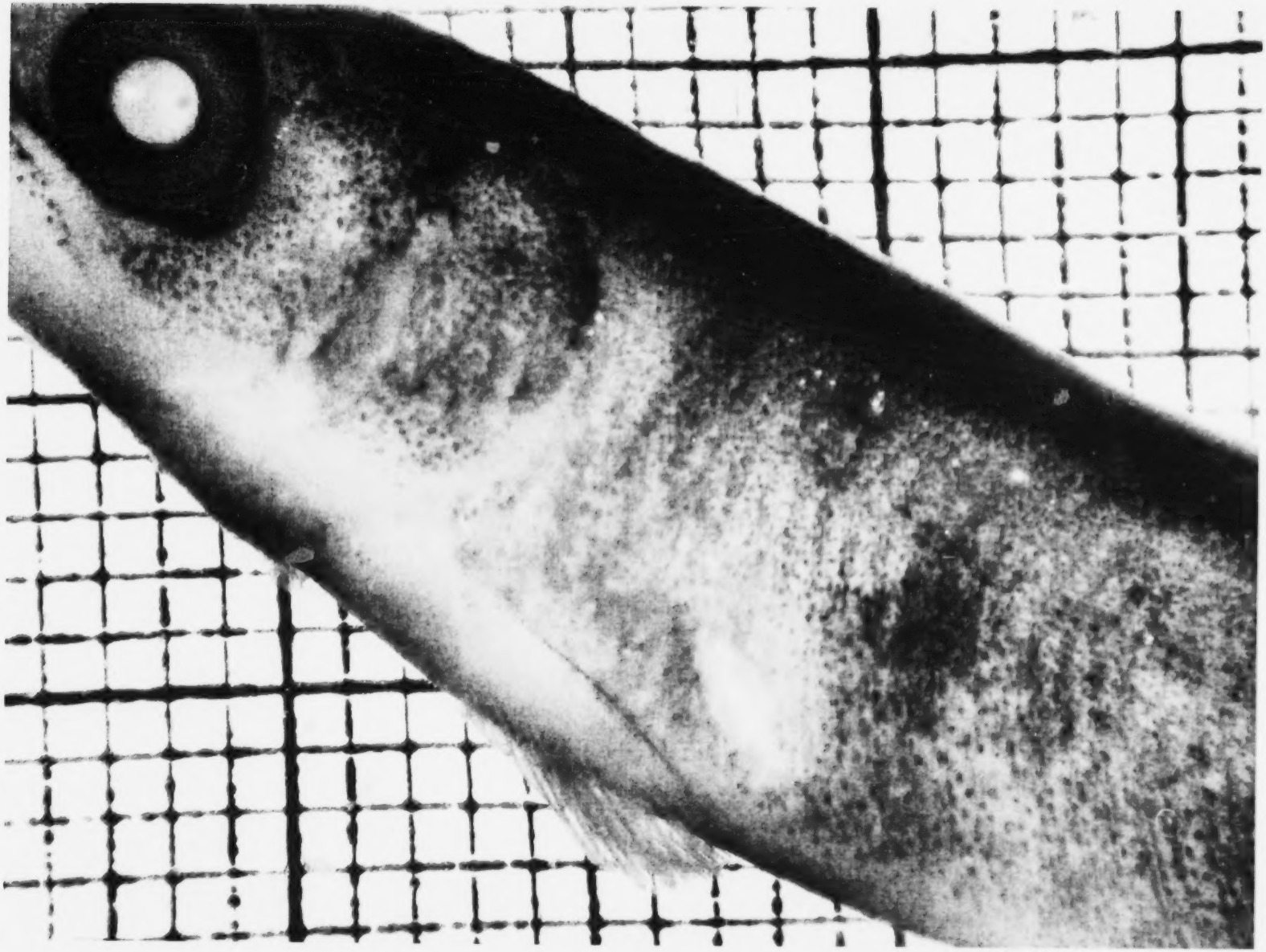
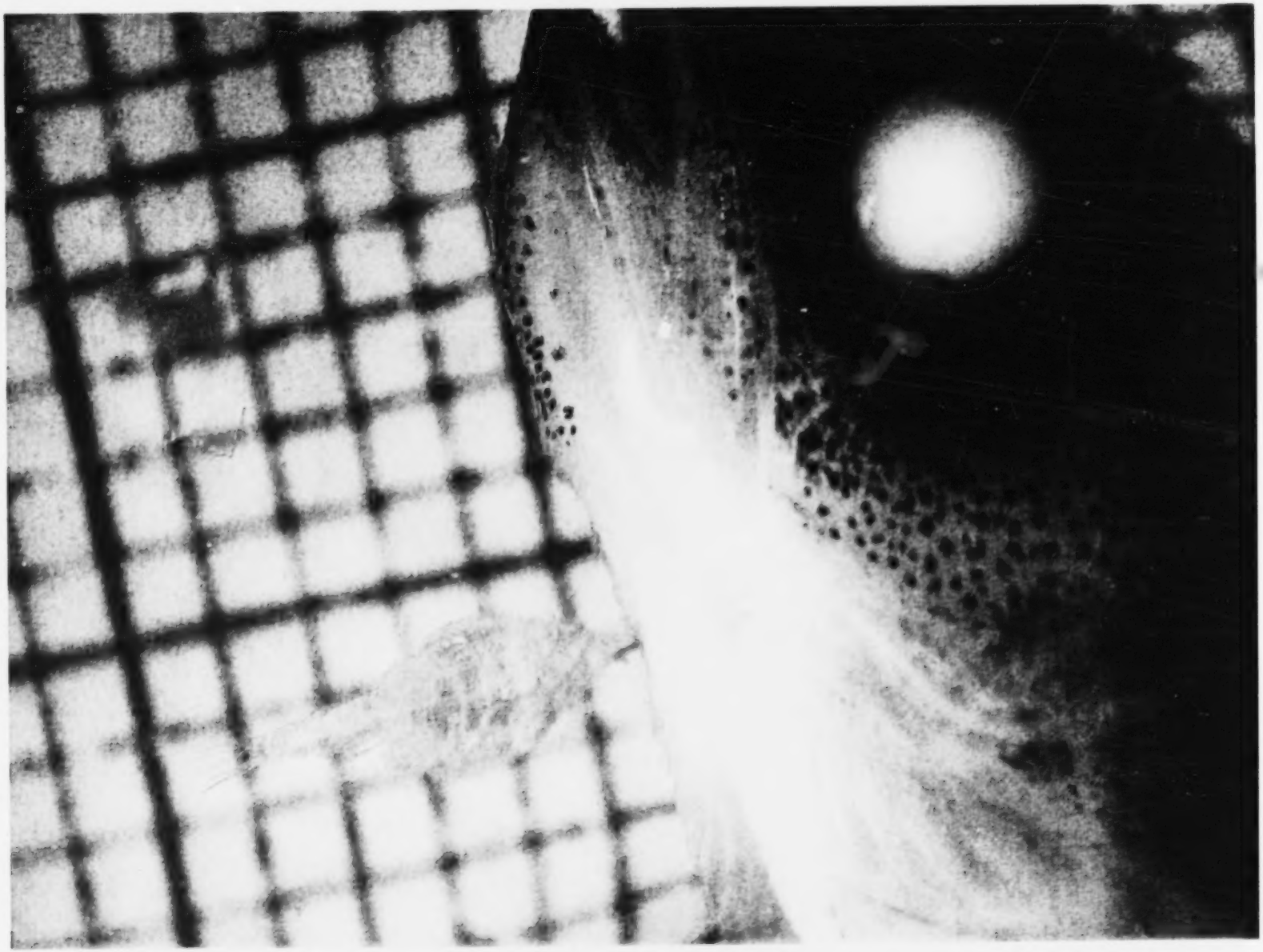
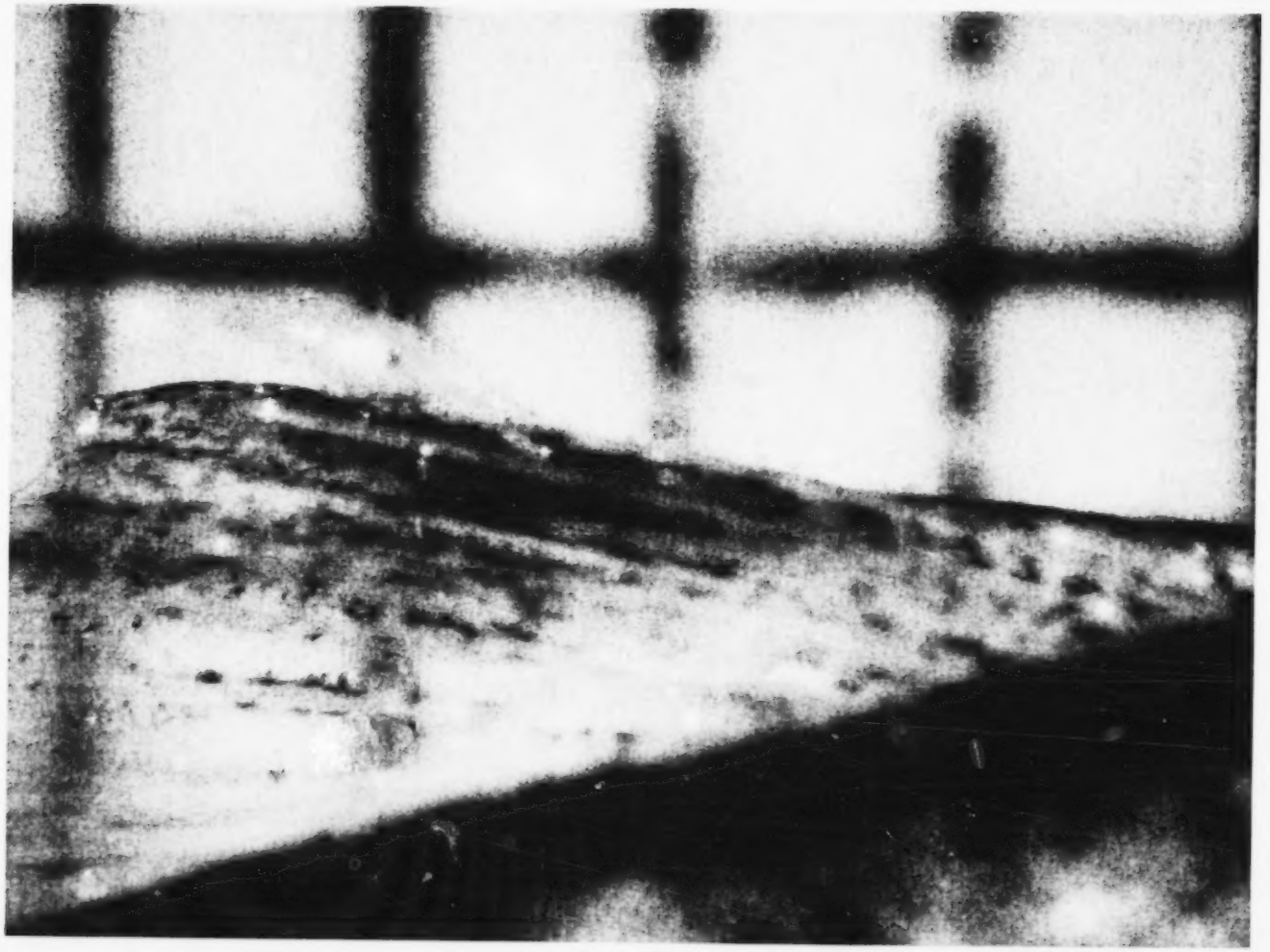
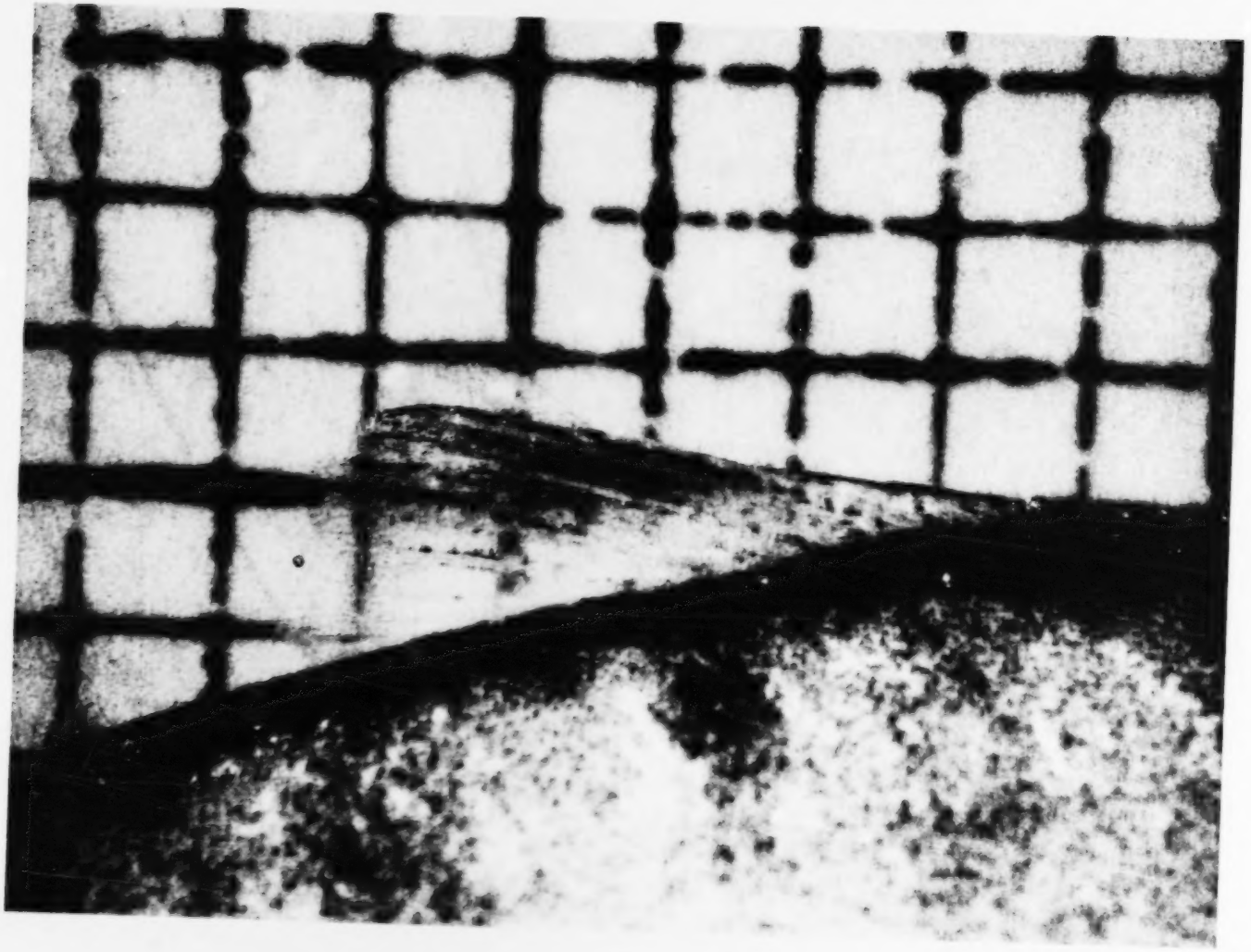
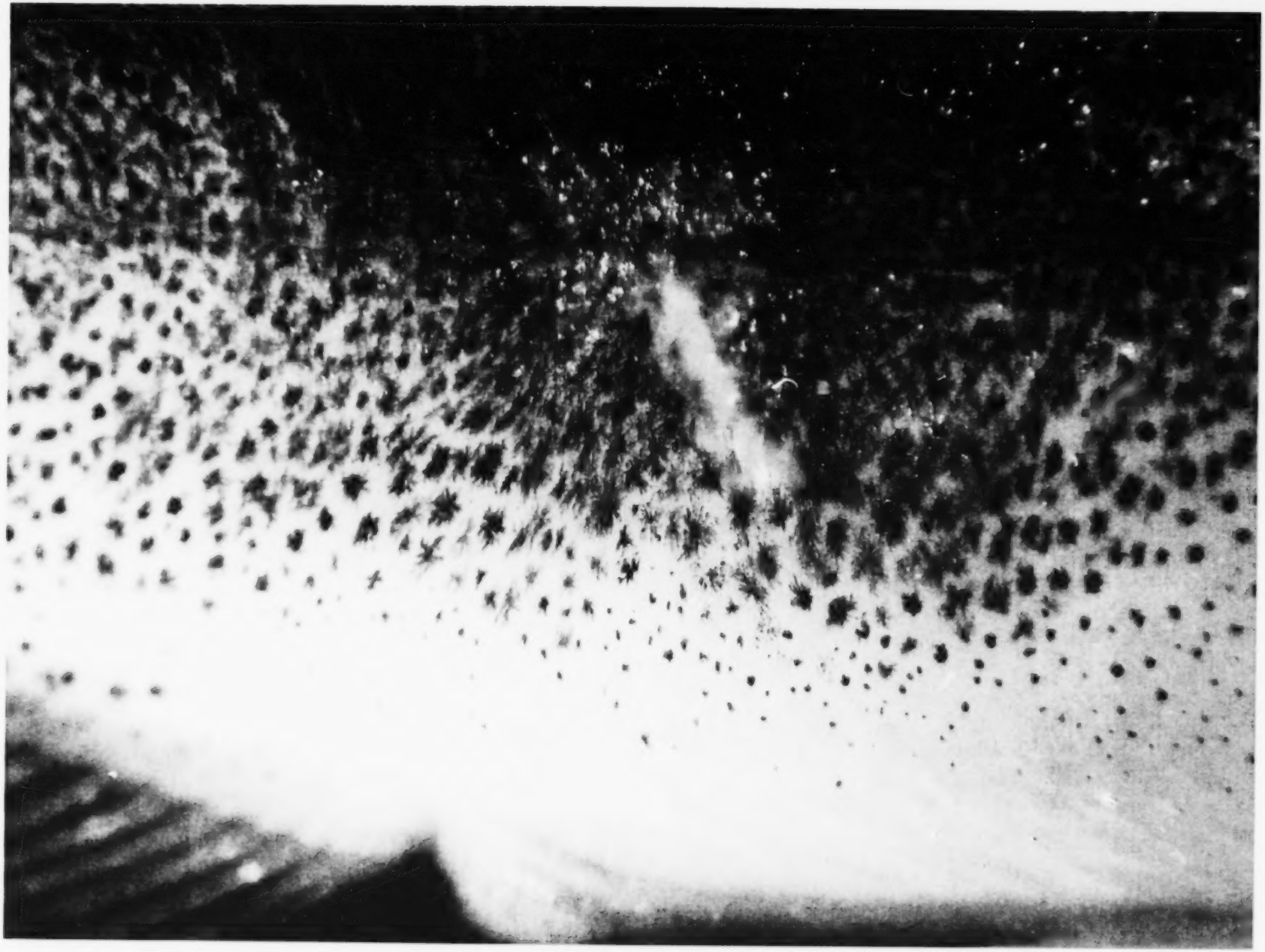


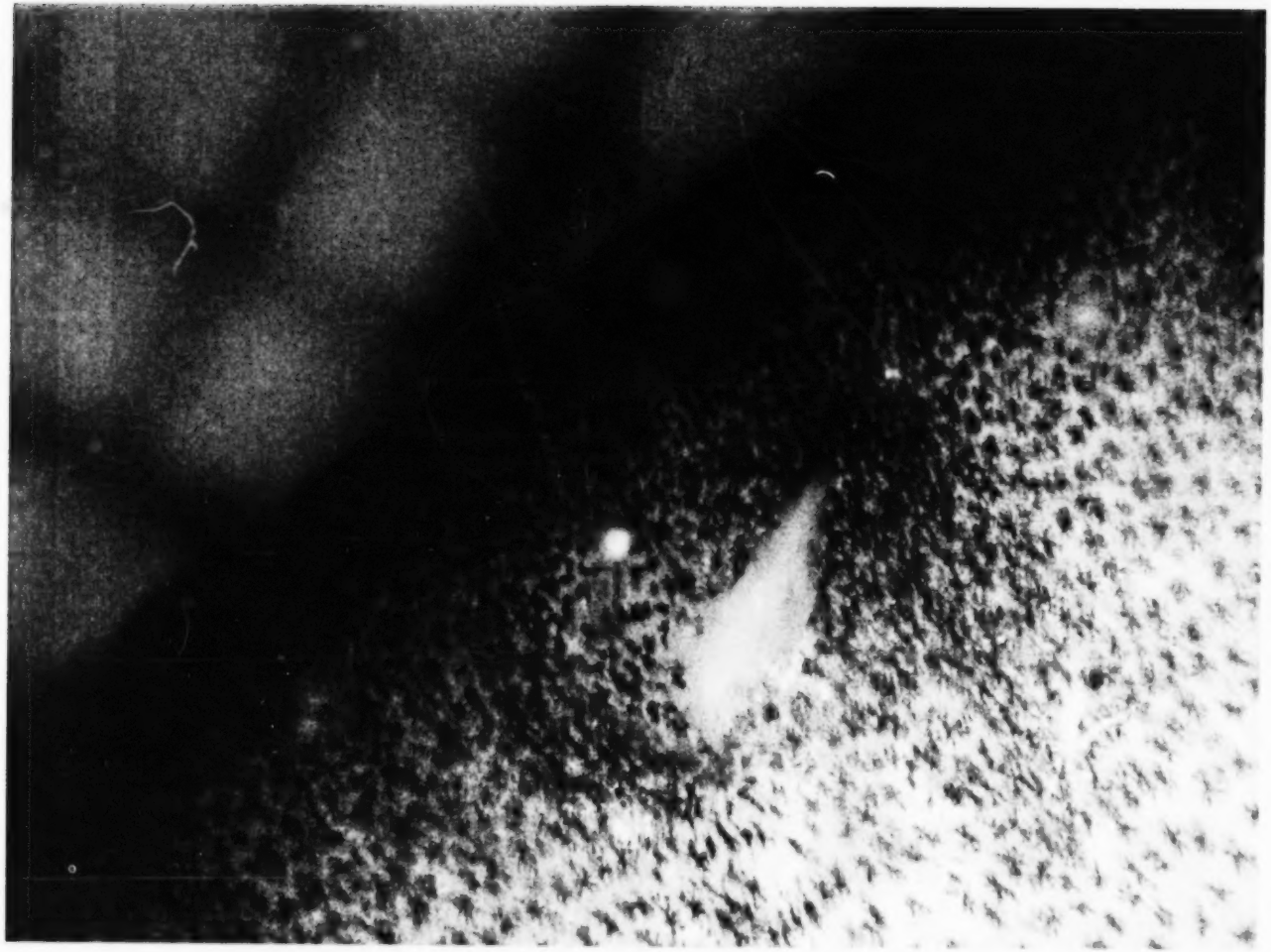


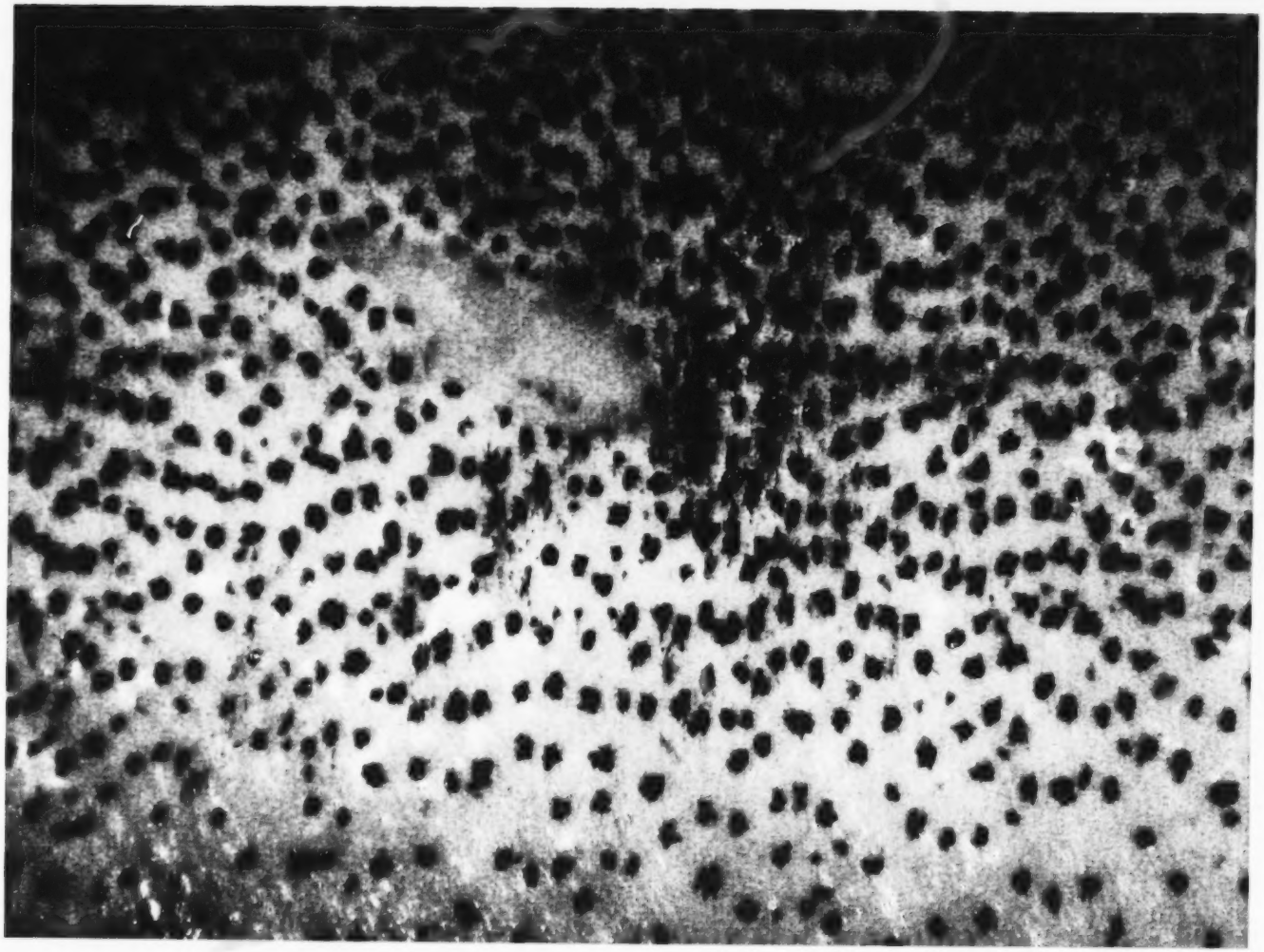


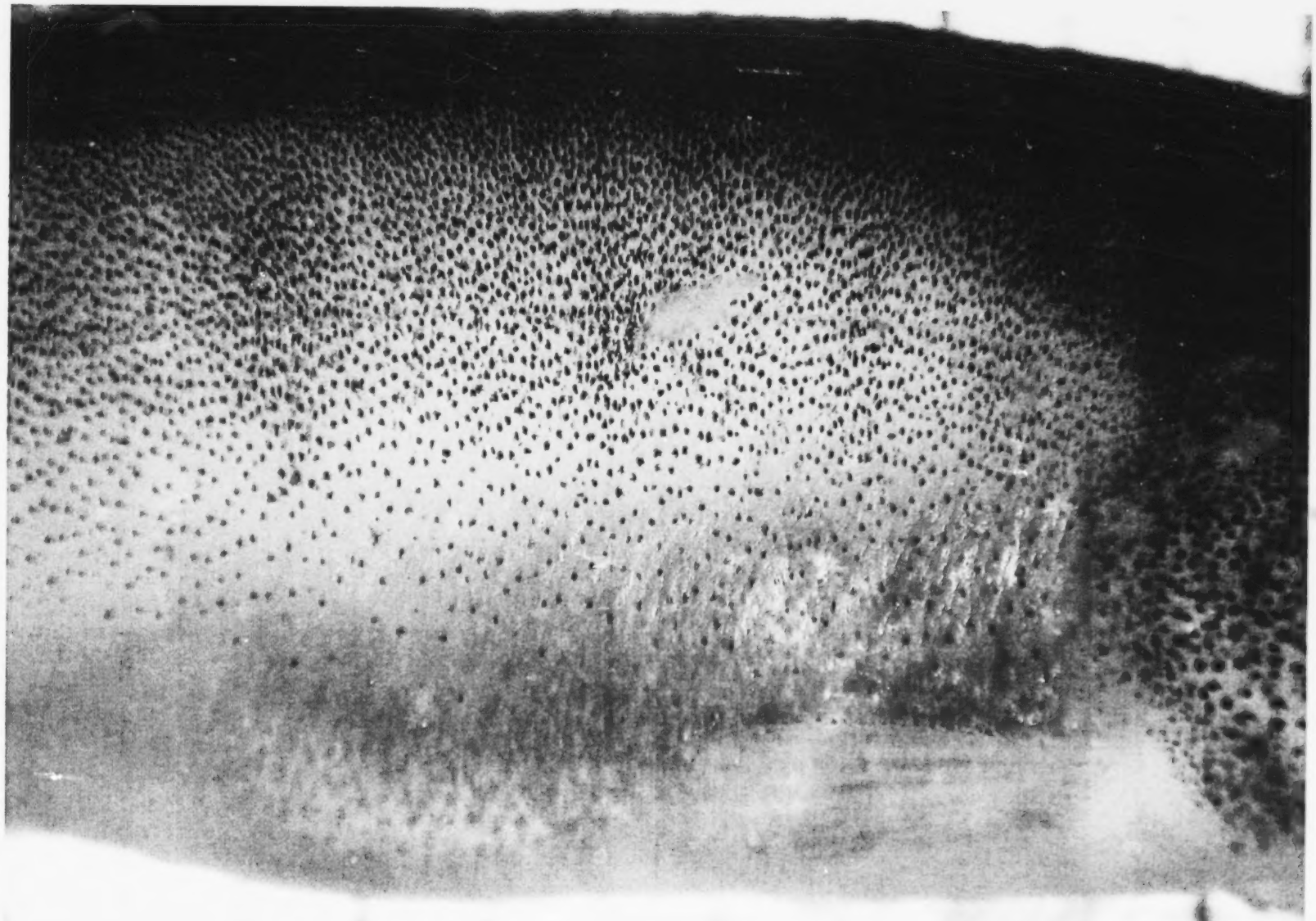


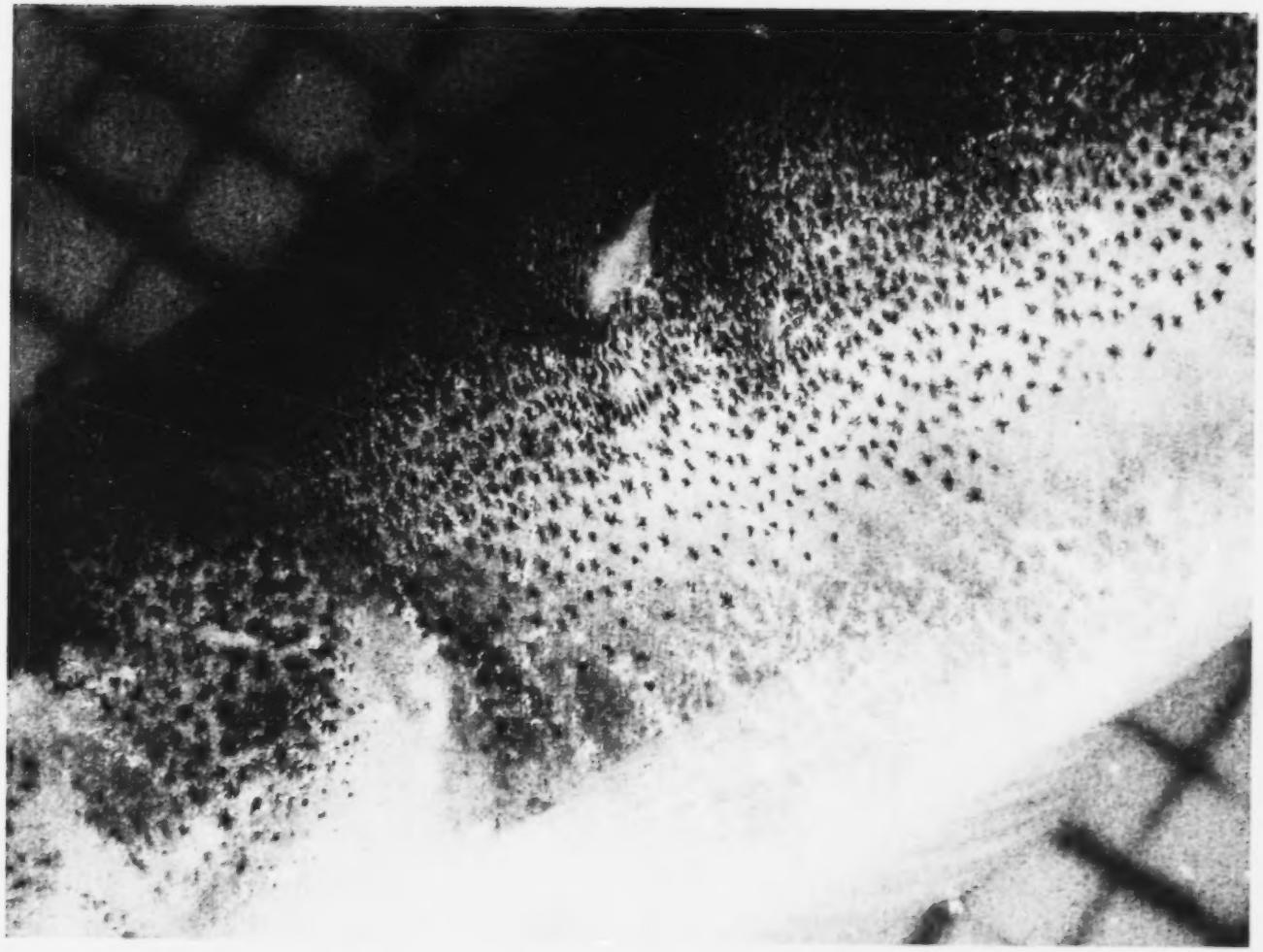


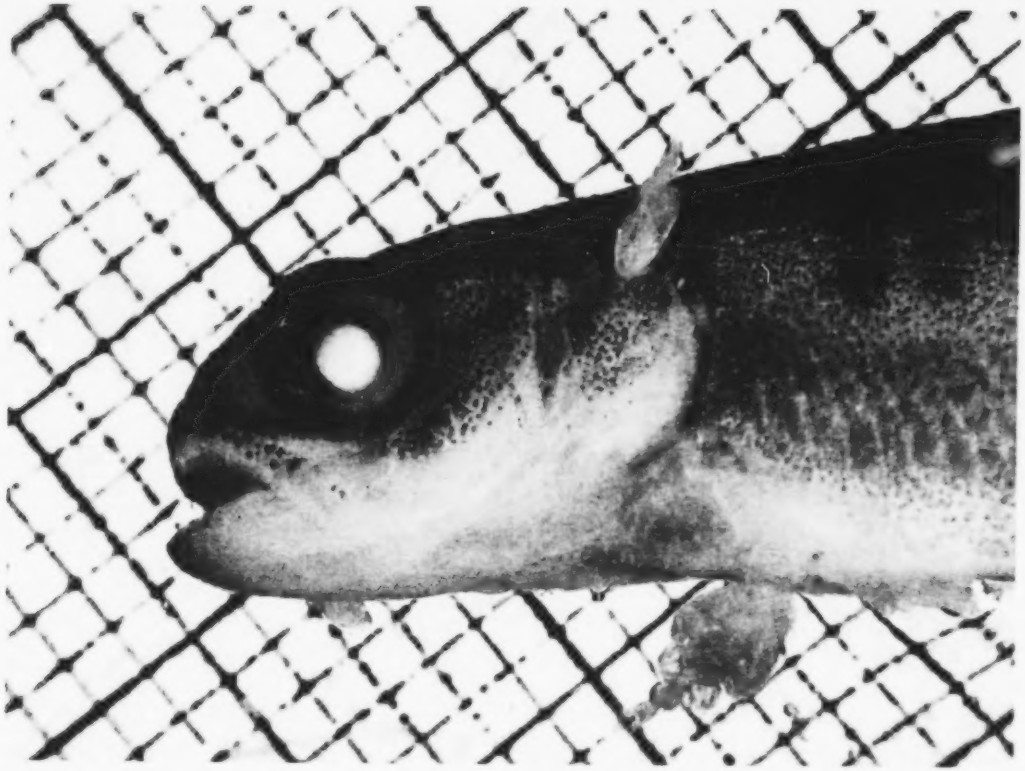




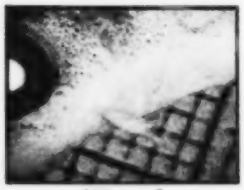


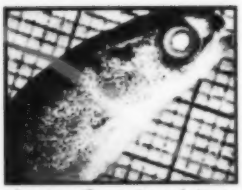




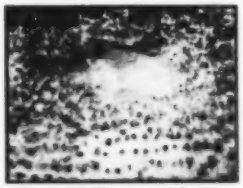


Pink with Lice


base of operculum.jpg


base of pectoral.jpg

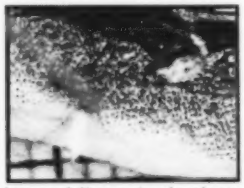
behind the head.jpg

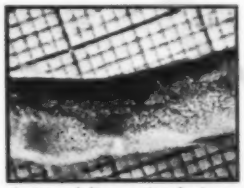

clem ch3 on pink.jpg

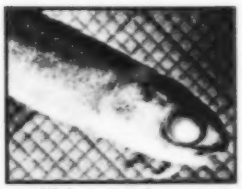
dorsal fin.jpg

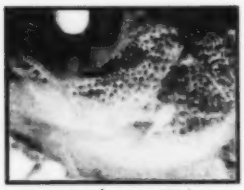
eye.jpg

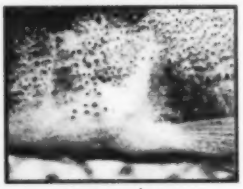
graze mark.jpg

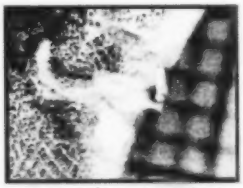

lateral line pinch close up.jpg

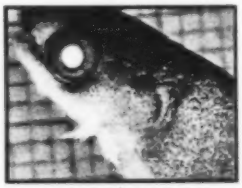

lateral line pinch.jpg

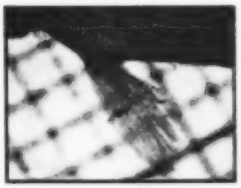

mandible attachment.jpg


operculum att.jpg

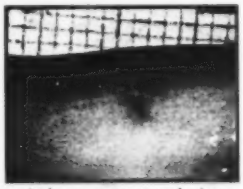

operculum attachment.jpg


operculum two.jpg

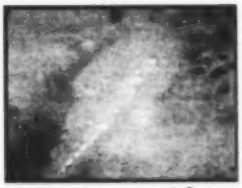

operculum.jpg

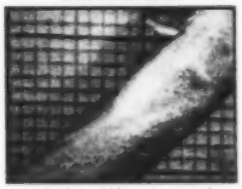

pectoral.jpg

pelvic.jpg


pink graze mark.jpg

pink lat line graze mark.jpg


pink salmonis ch3.jpg


pink with several attachements.jpg

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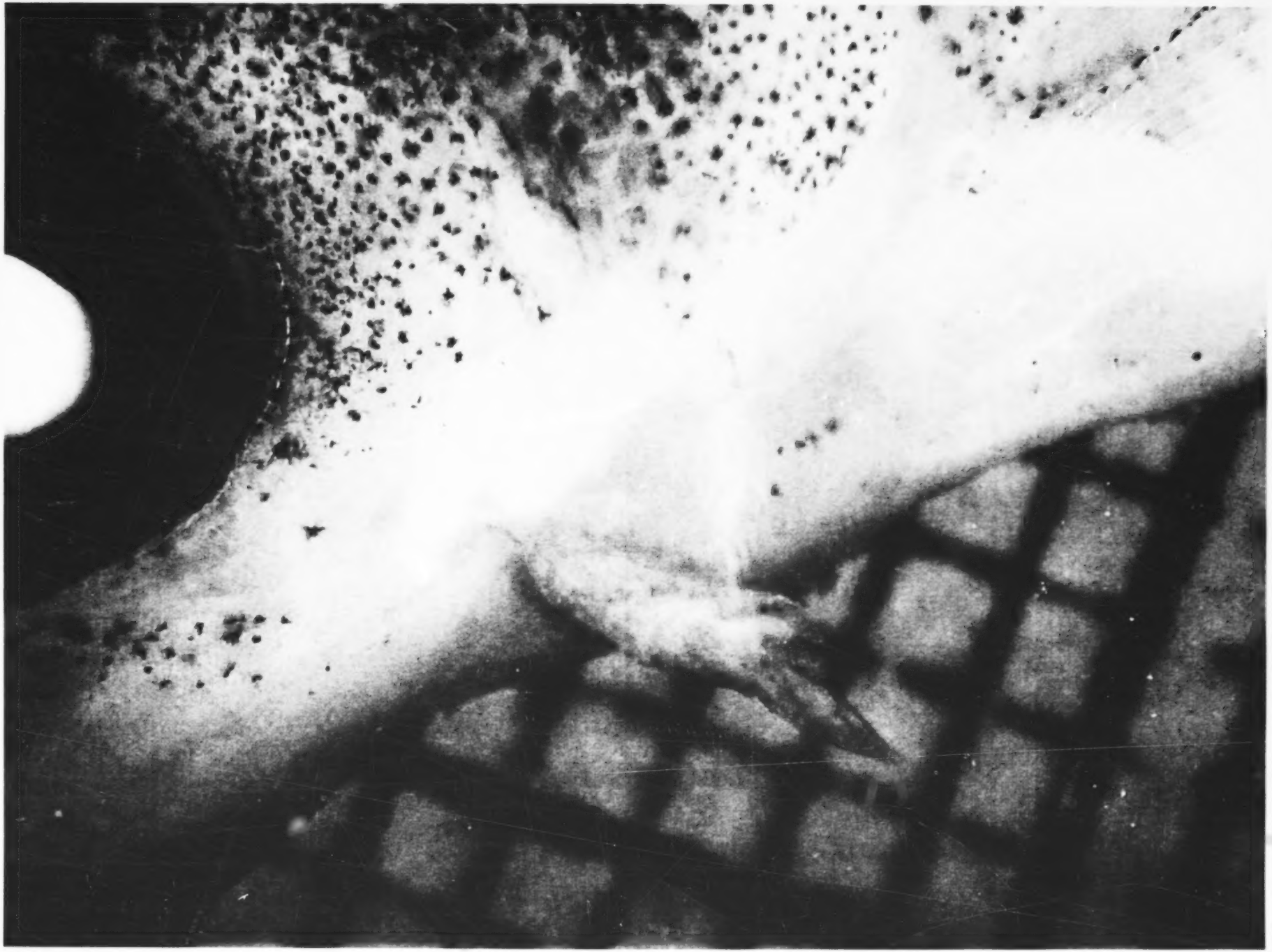
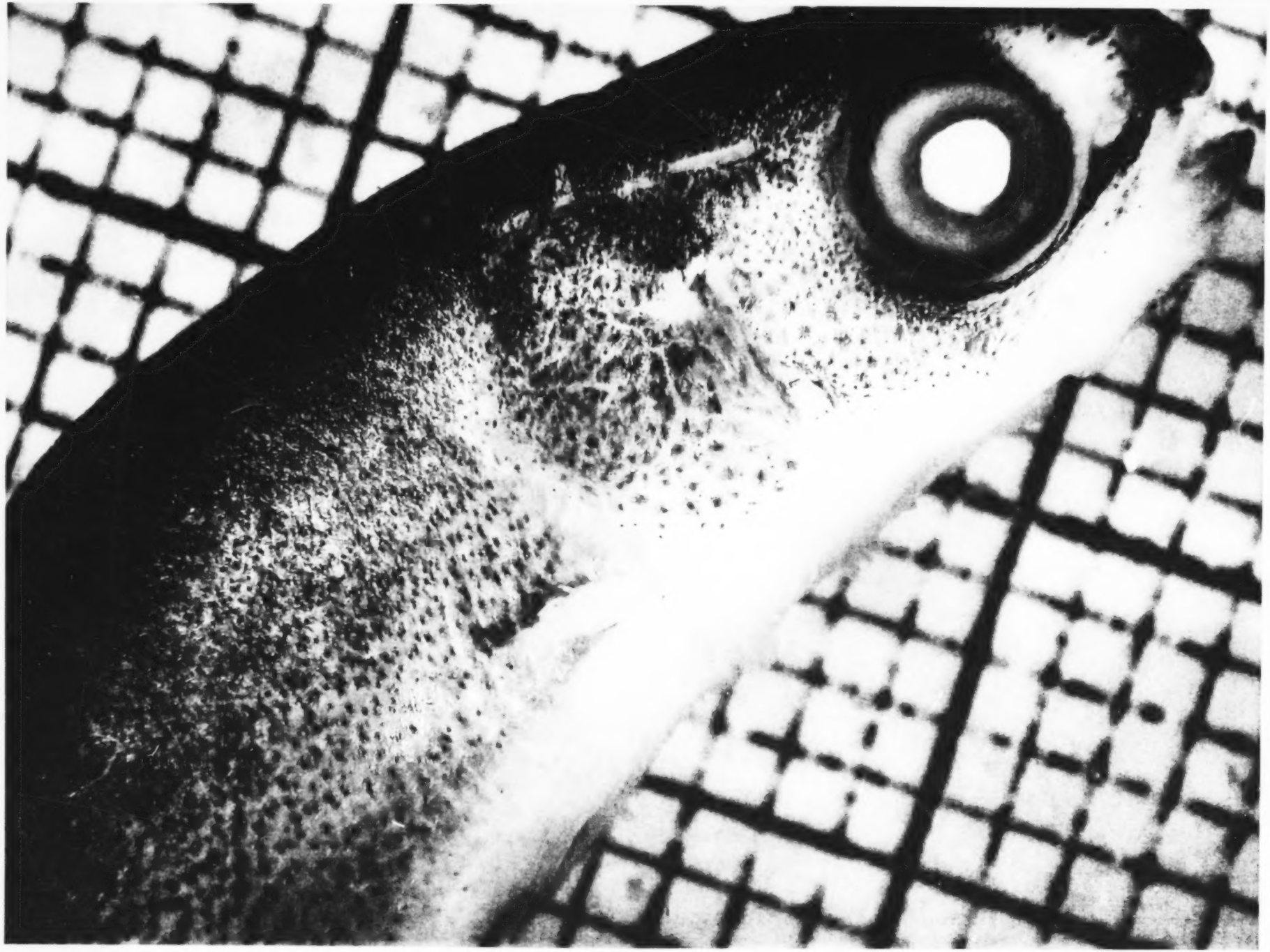
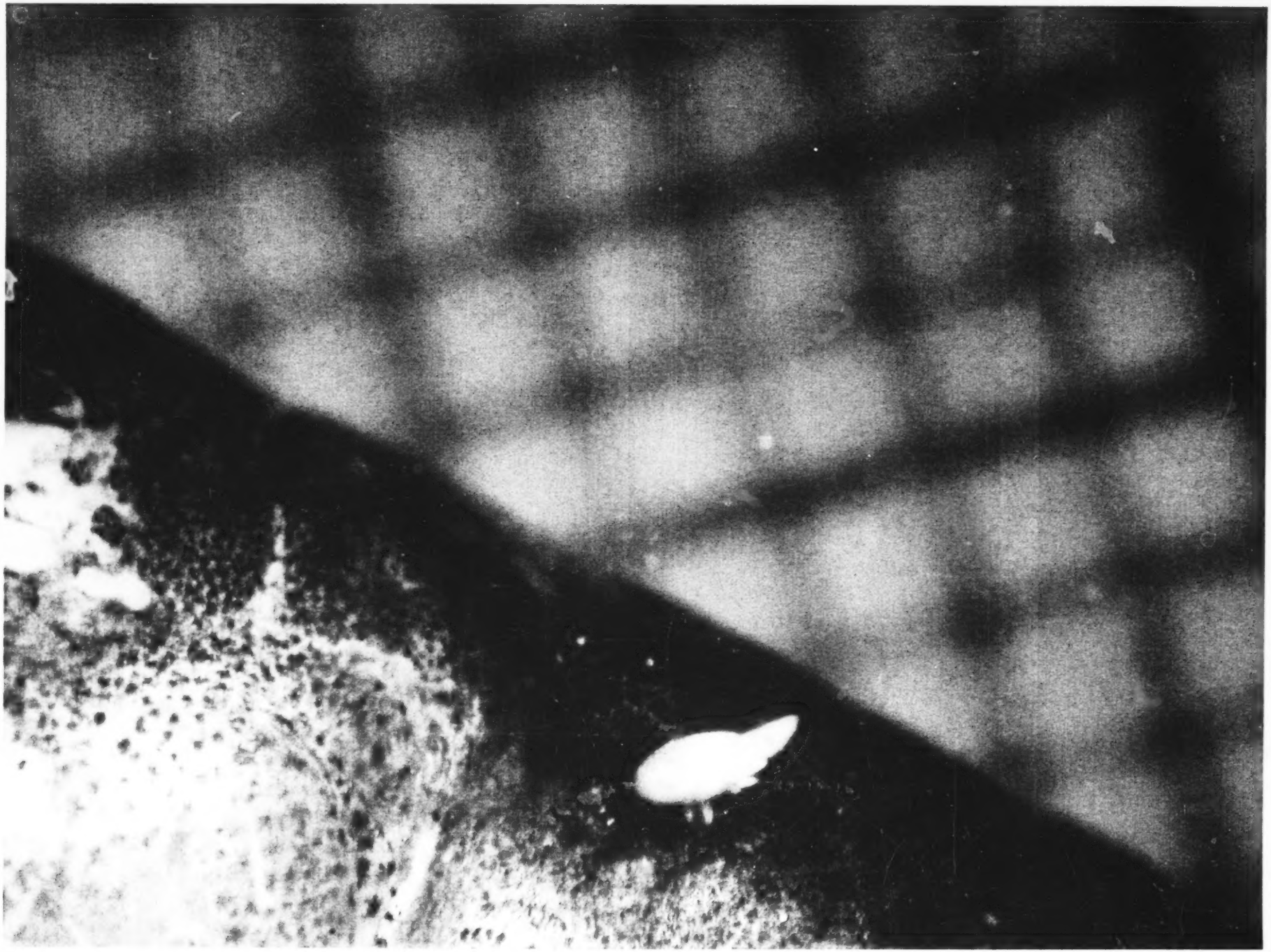
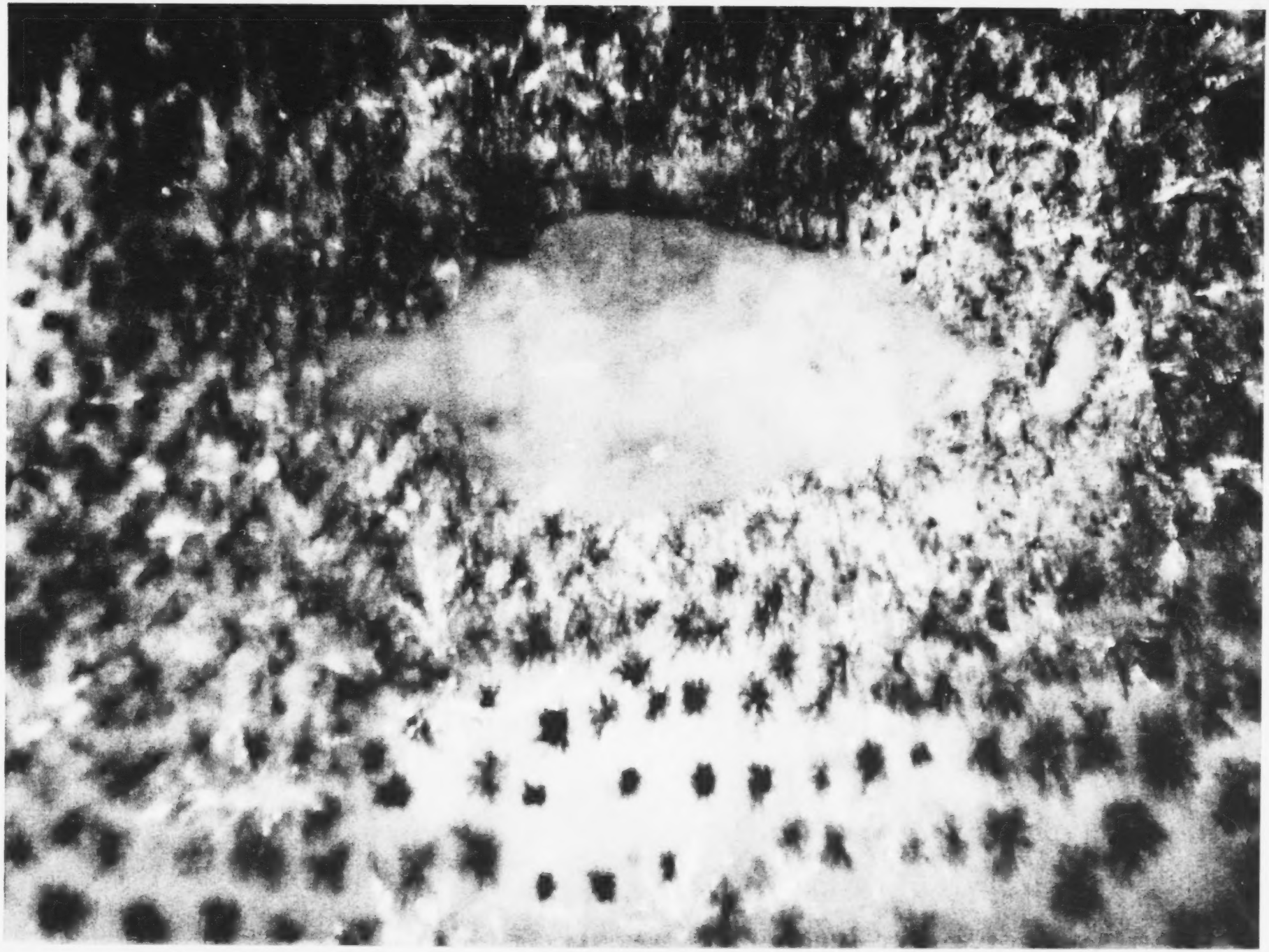
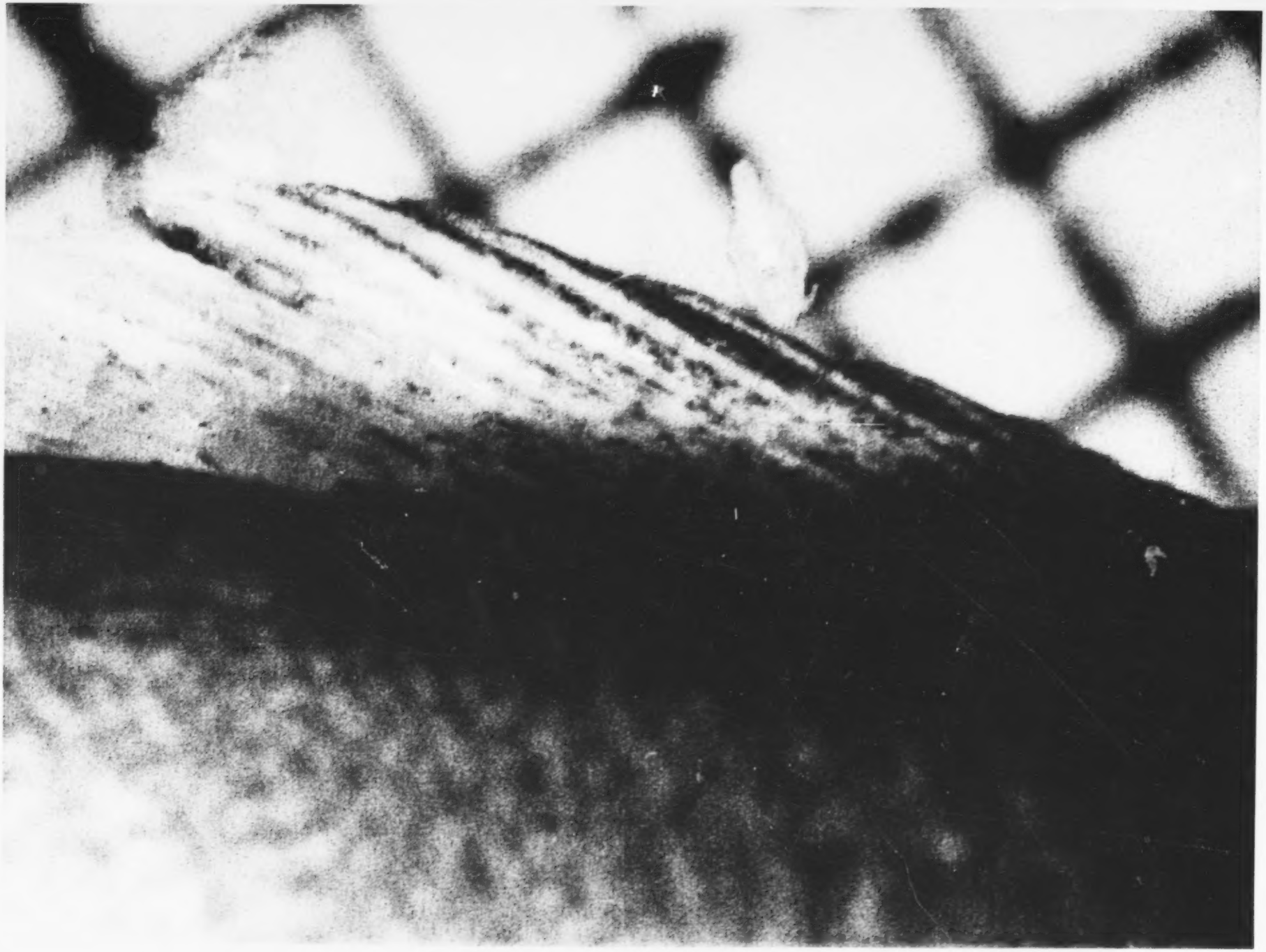
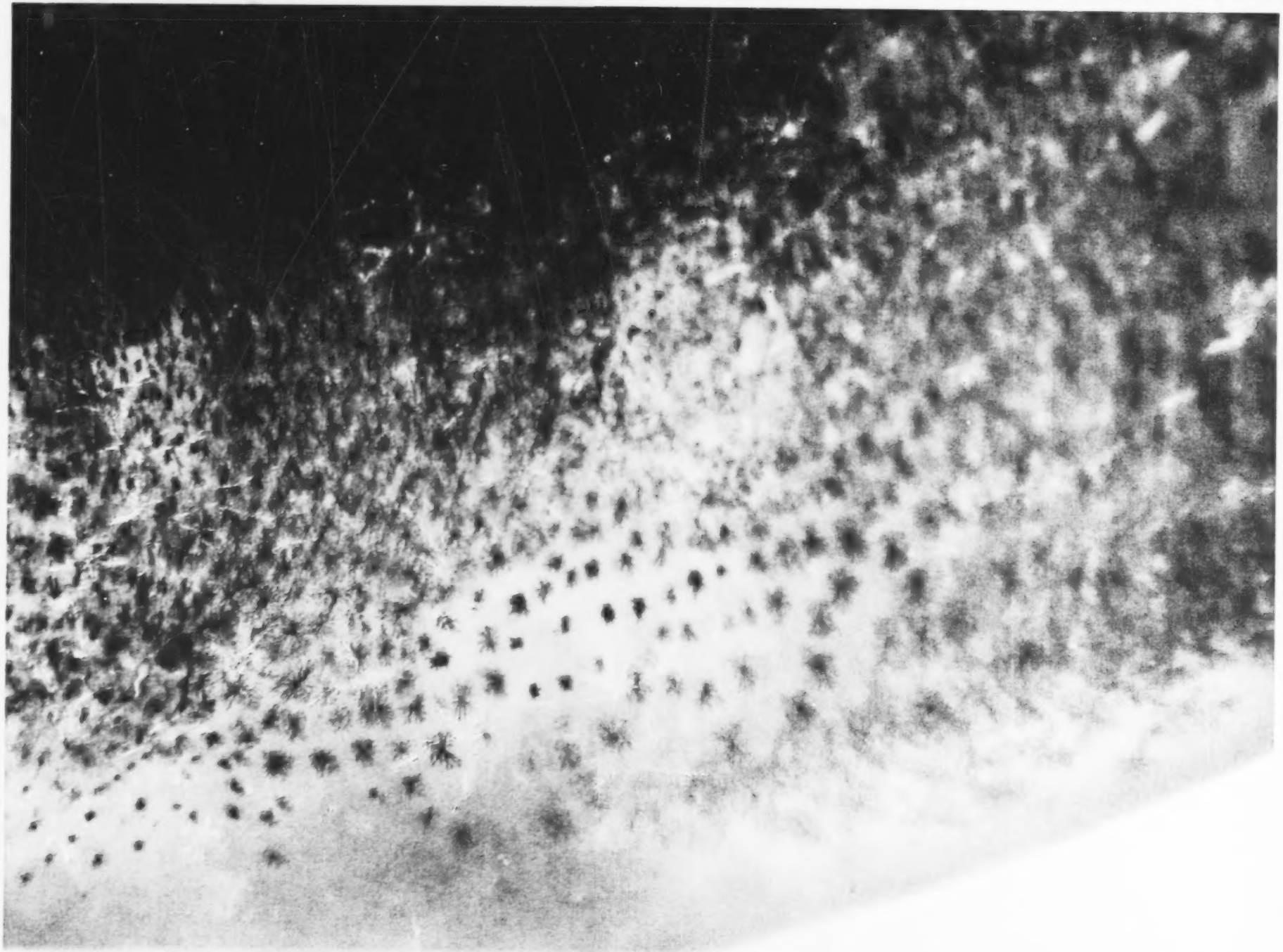


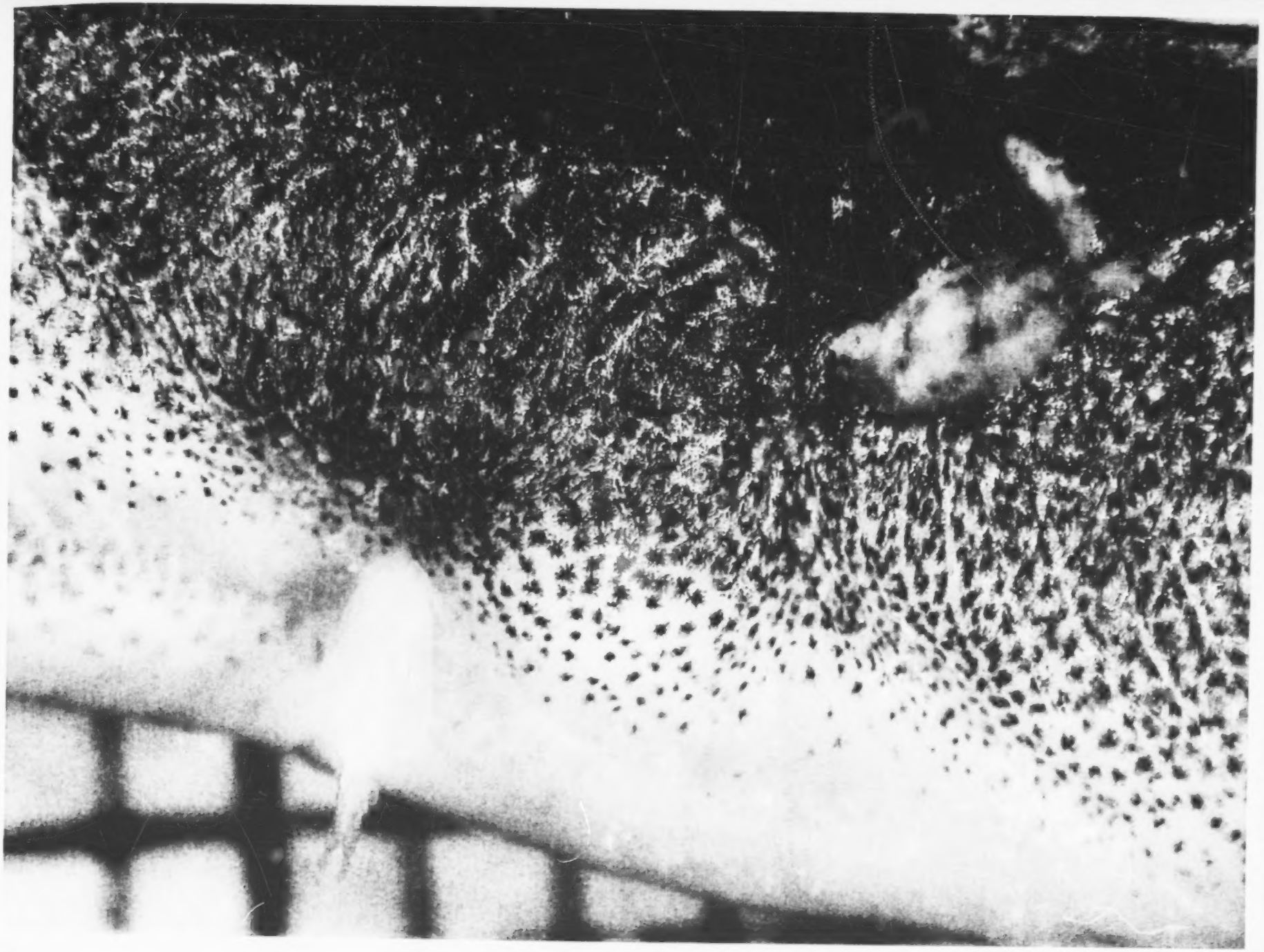


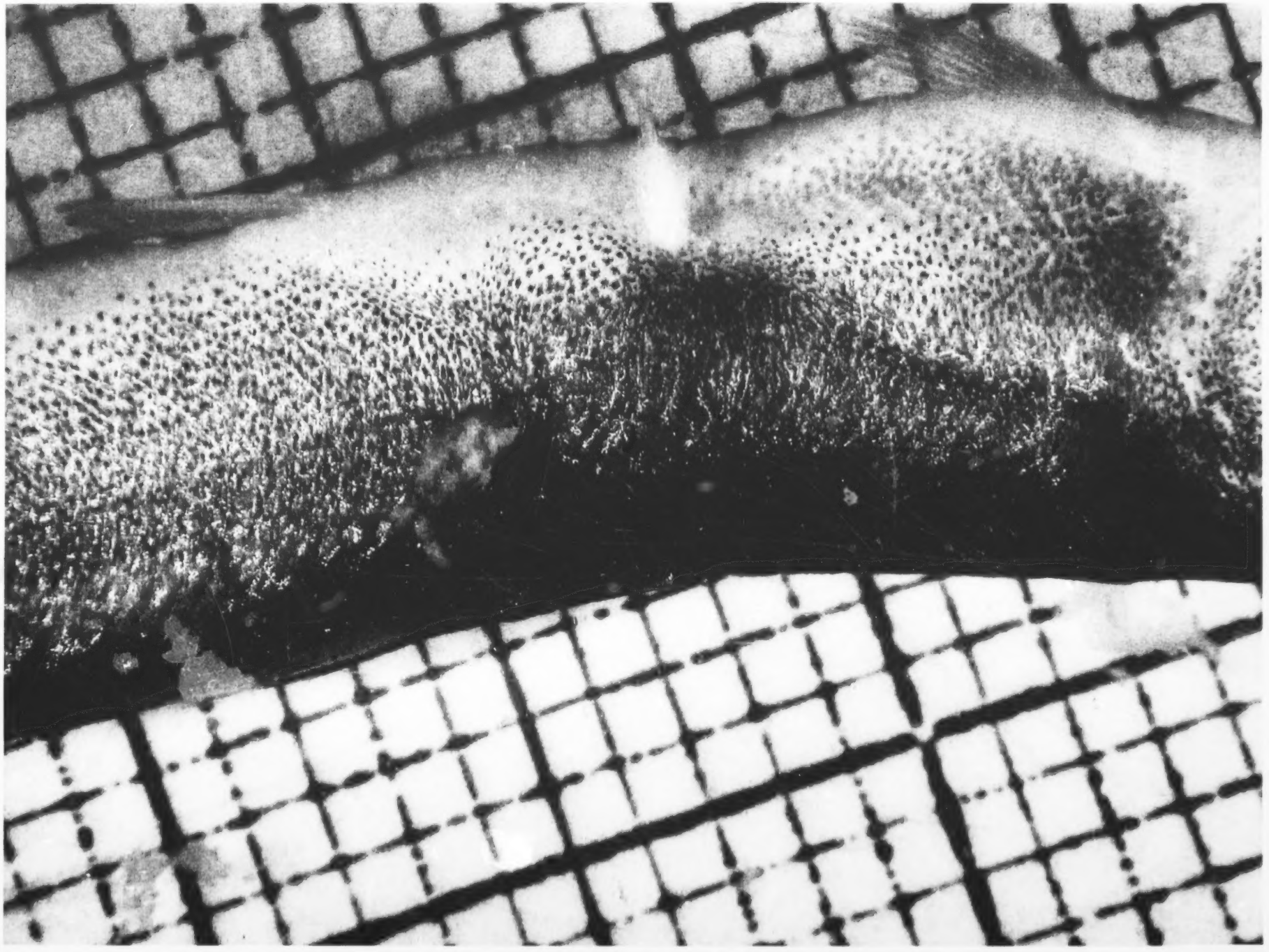


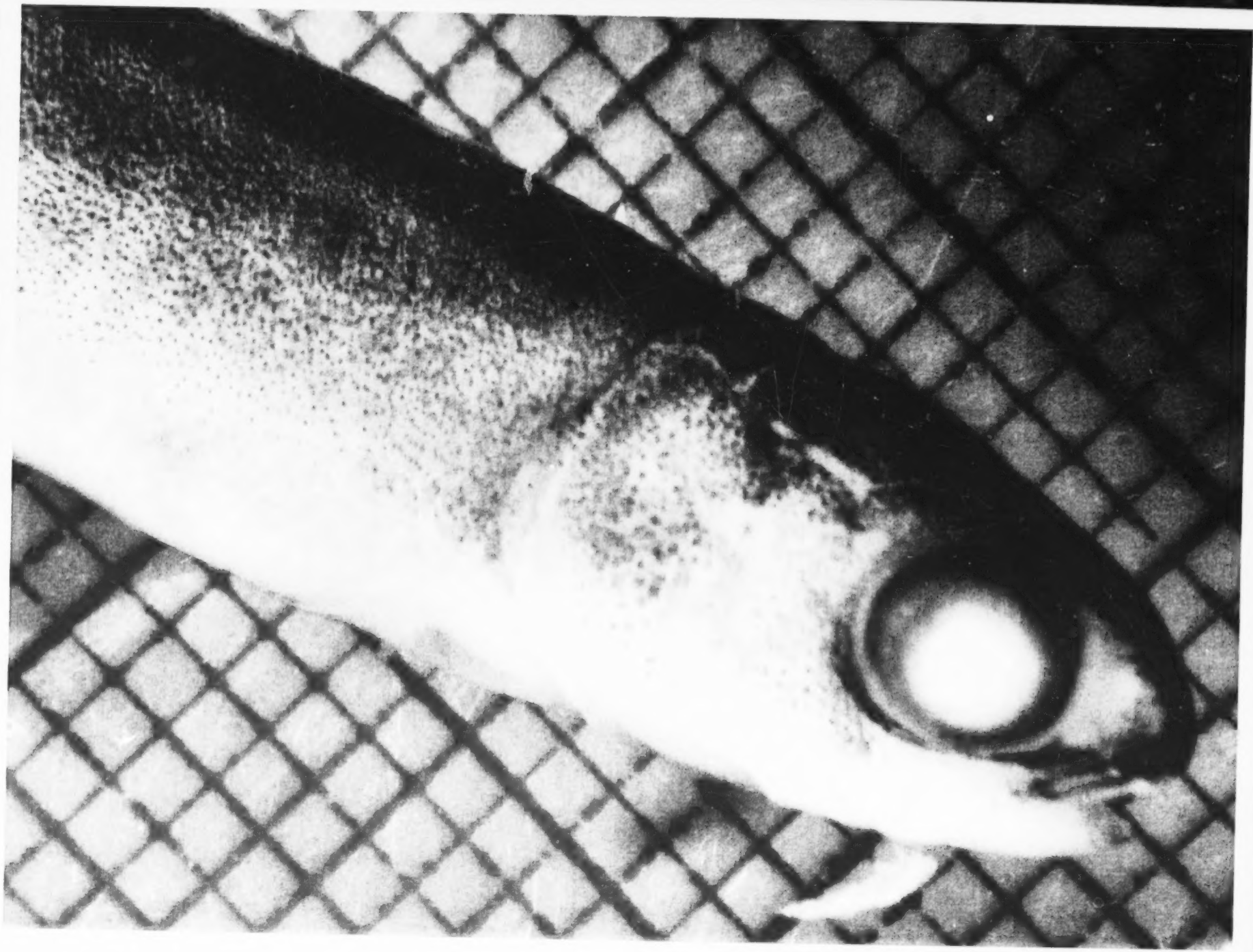


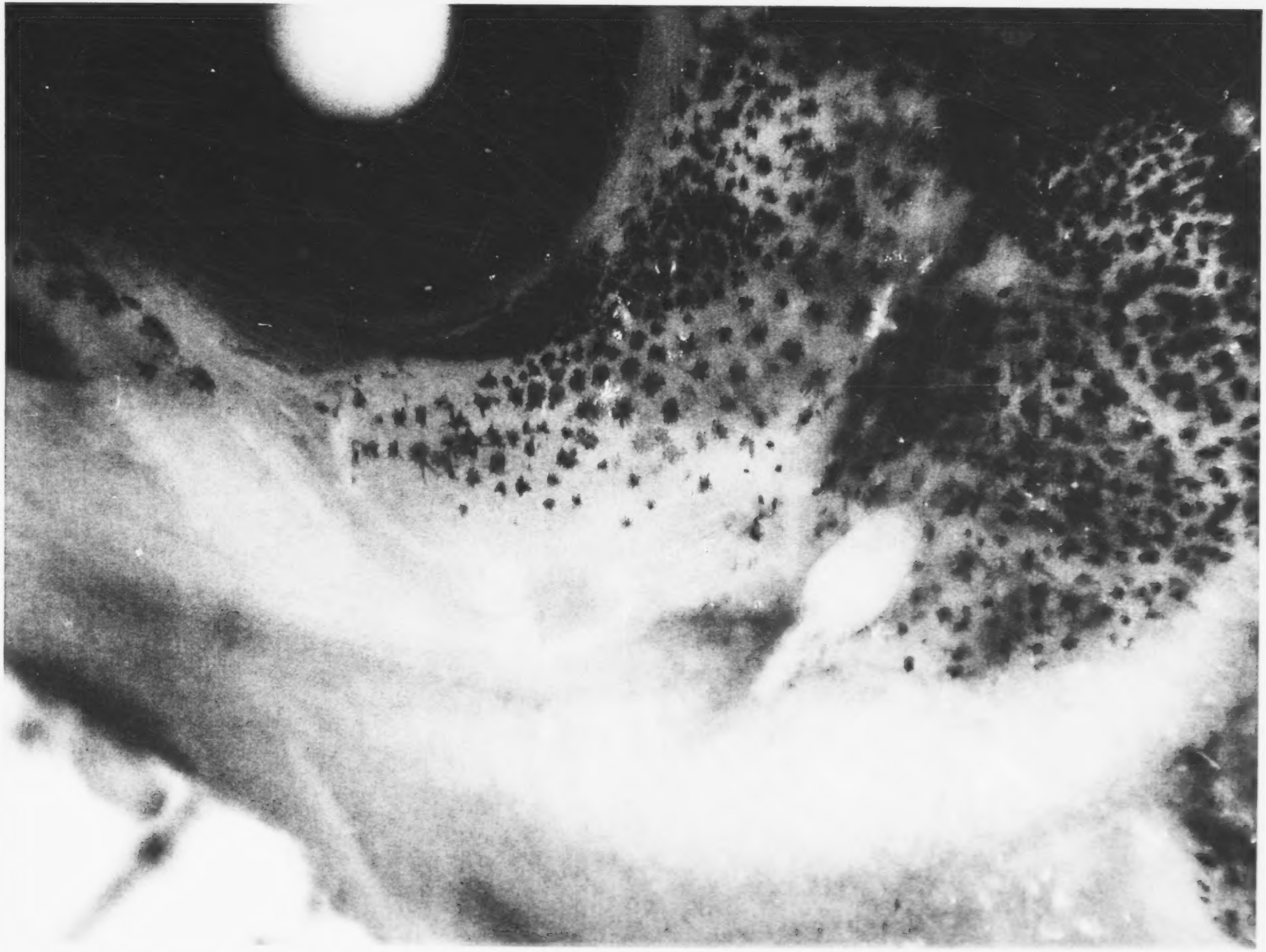


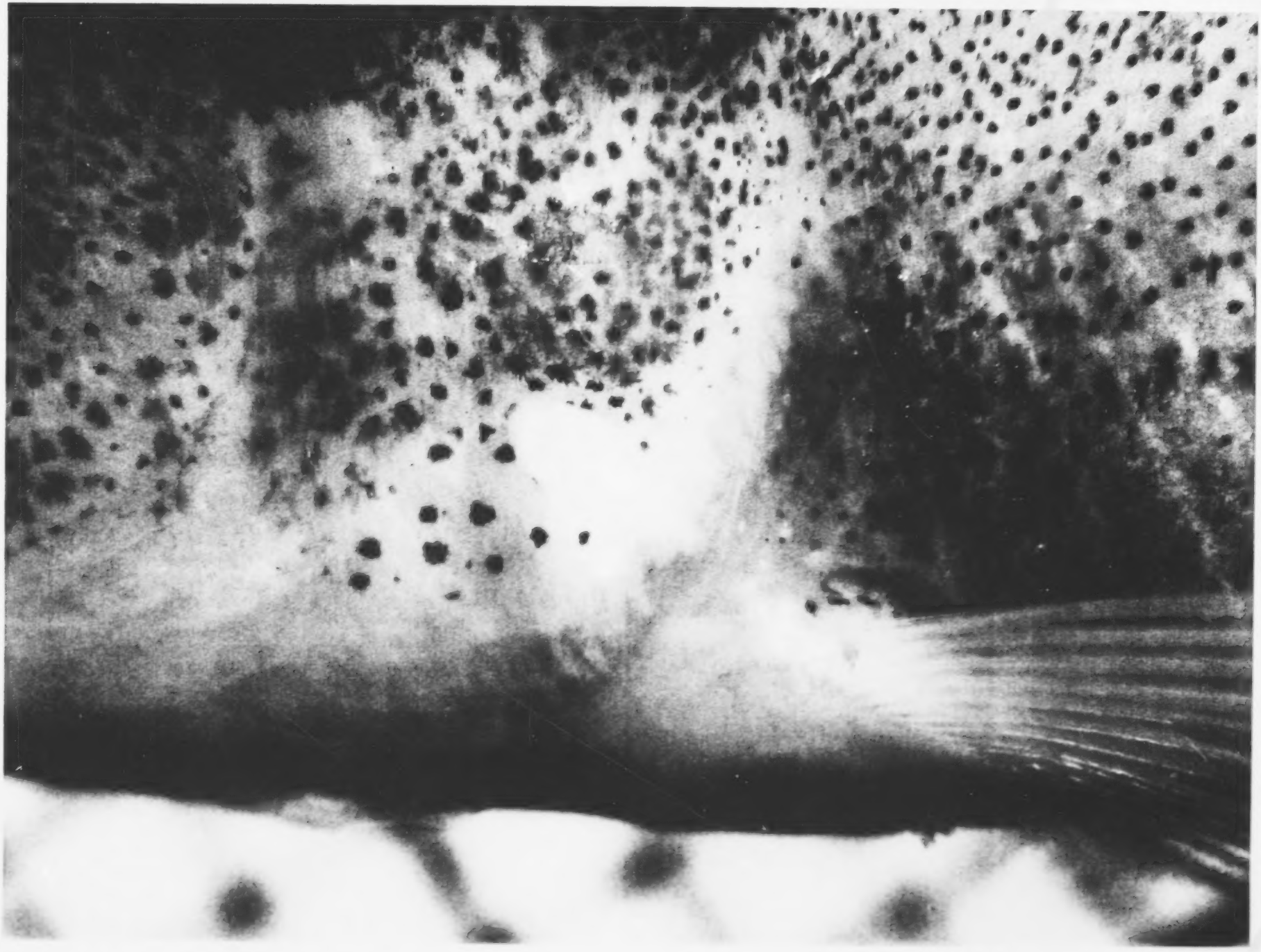


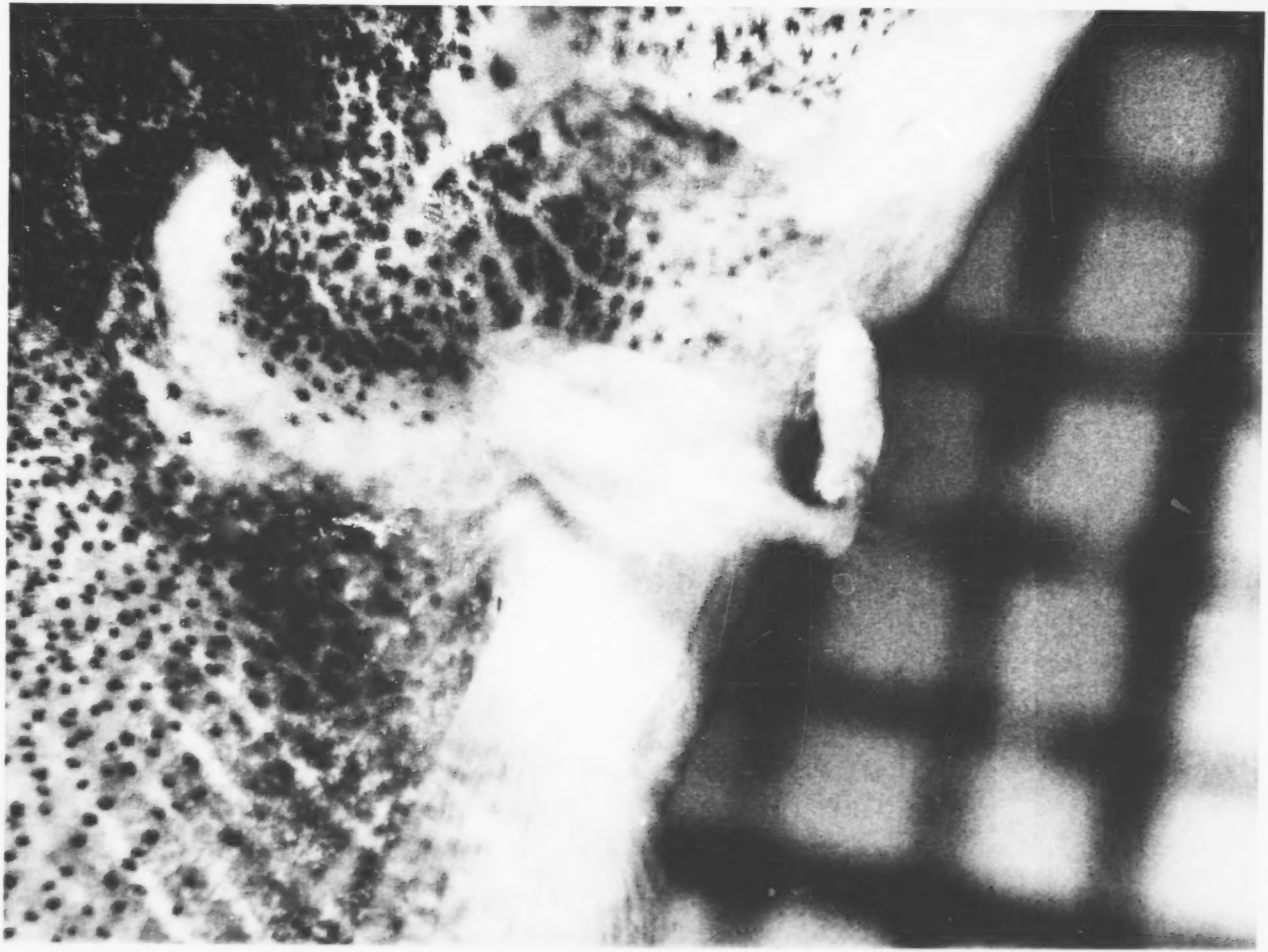


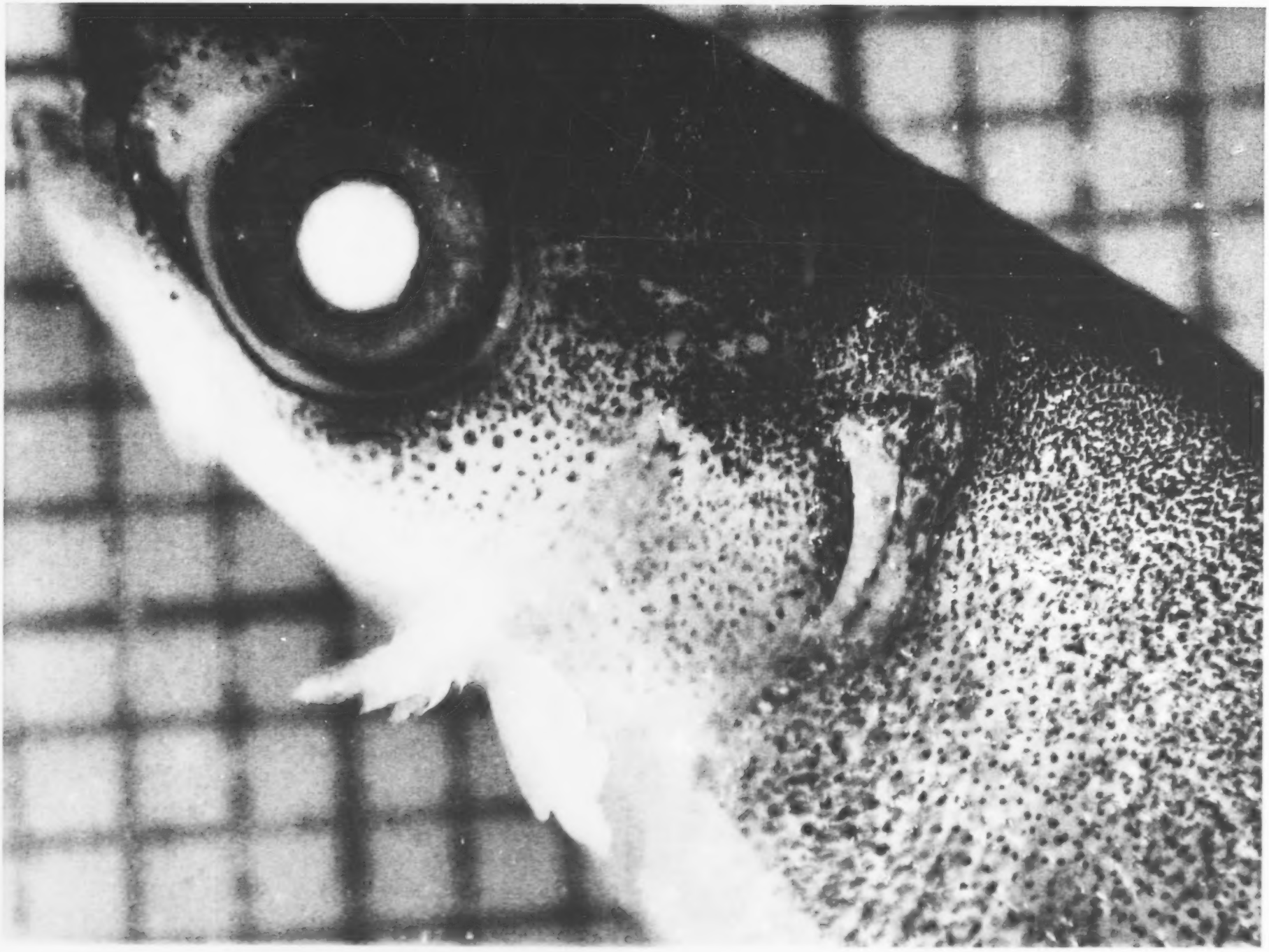


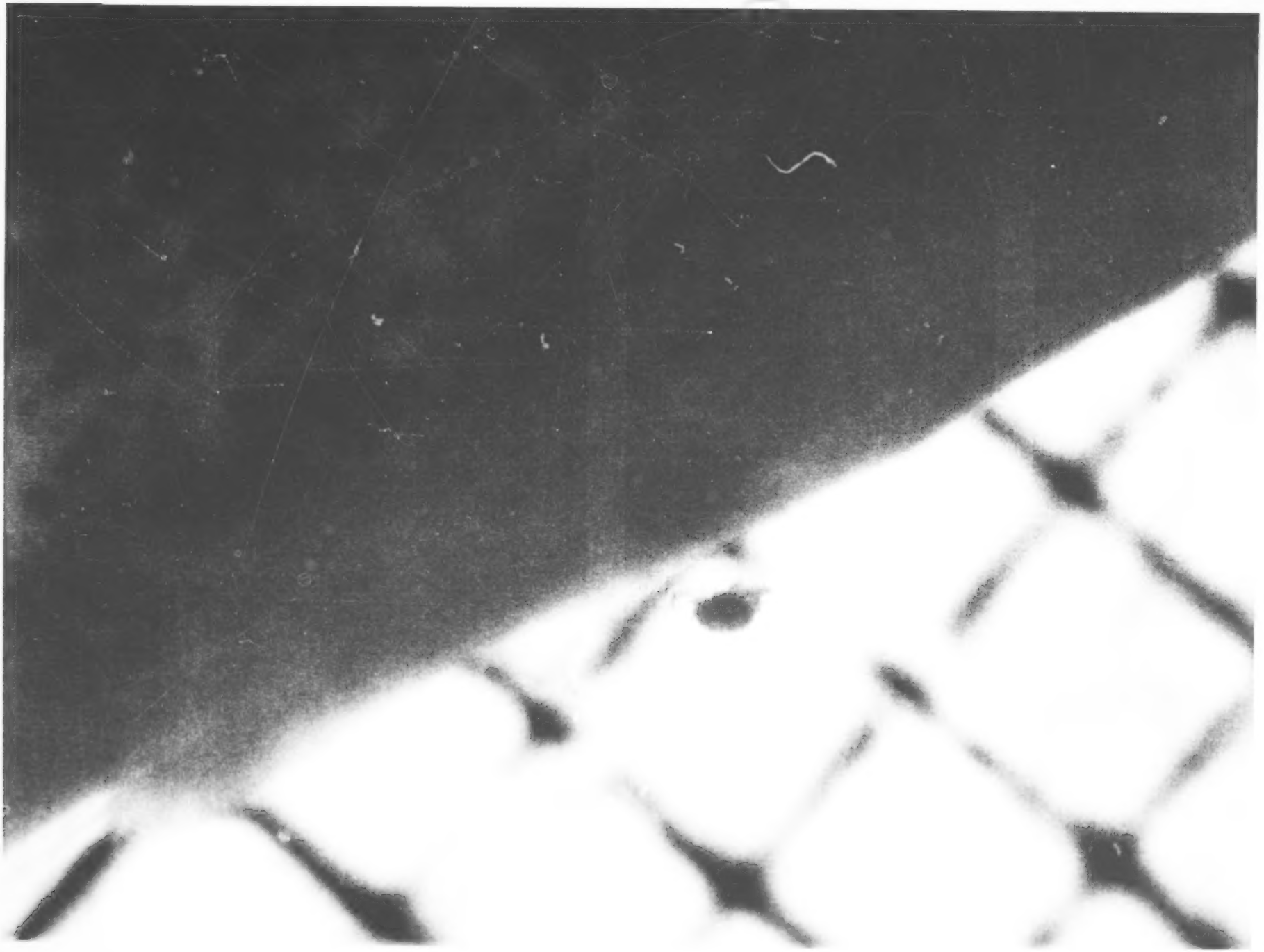


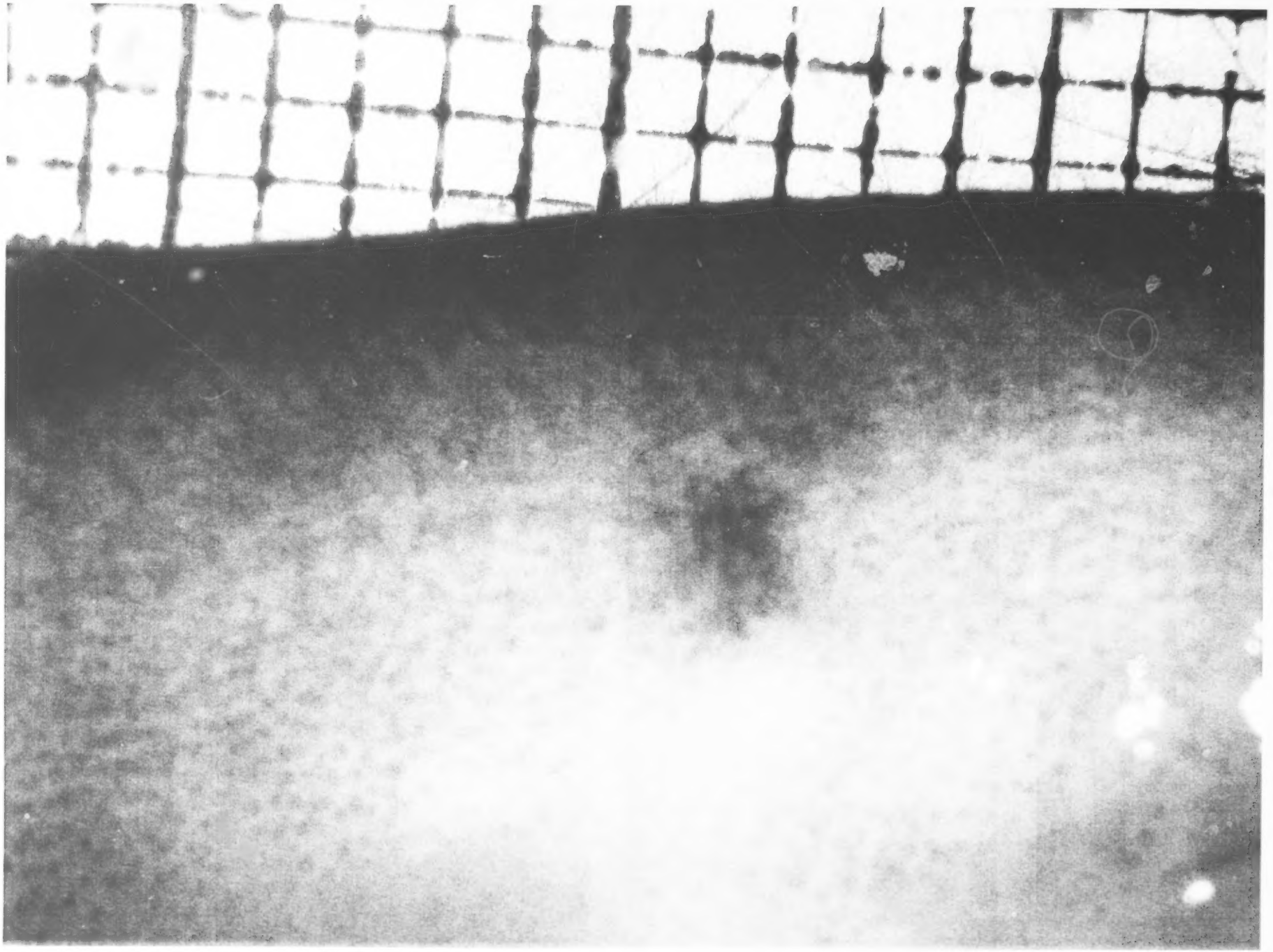


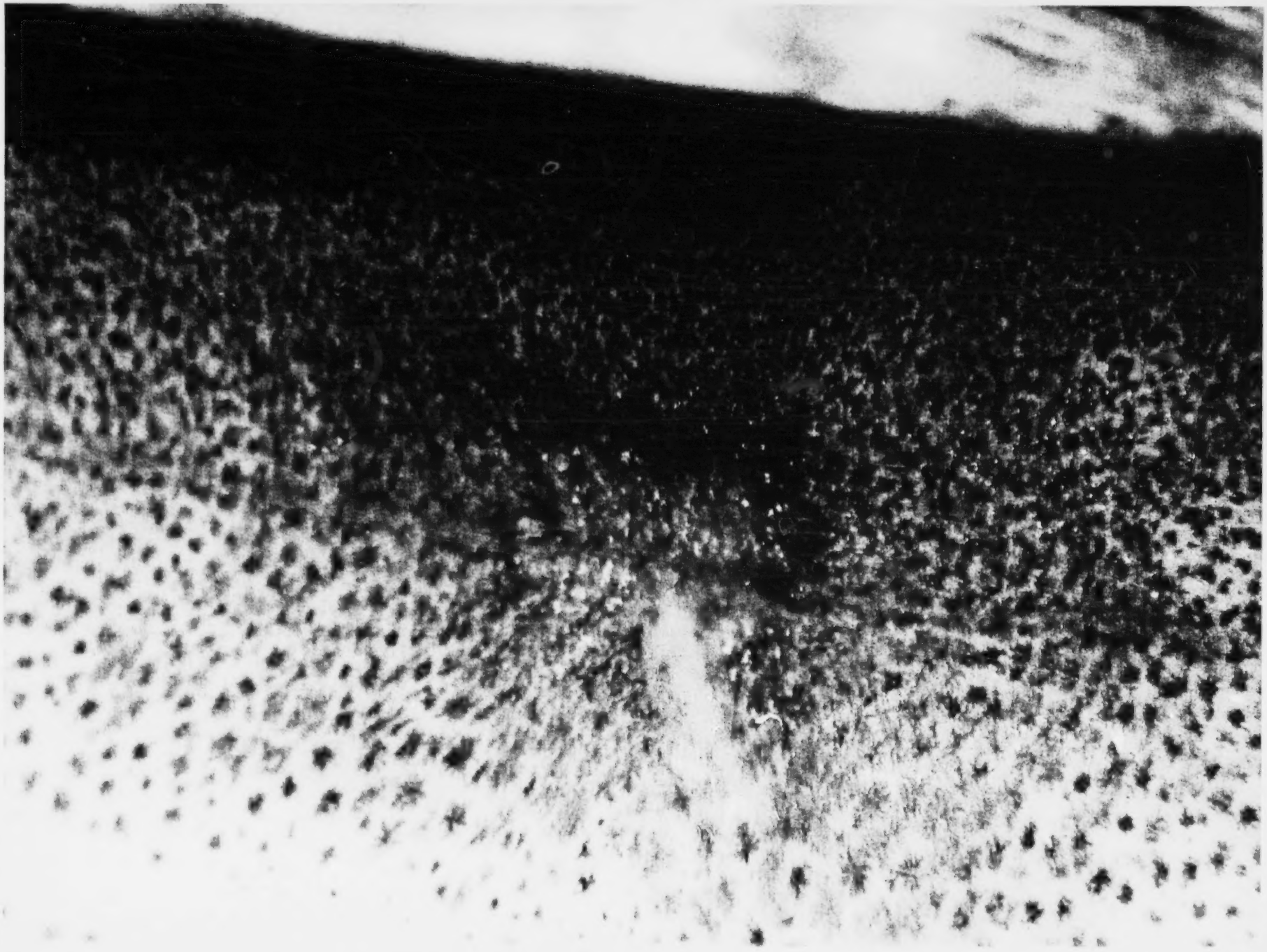


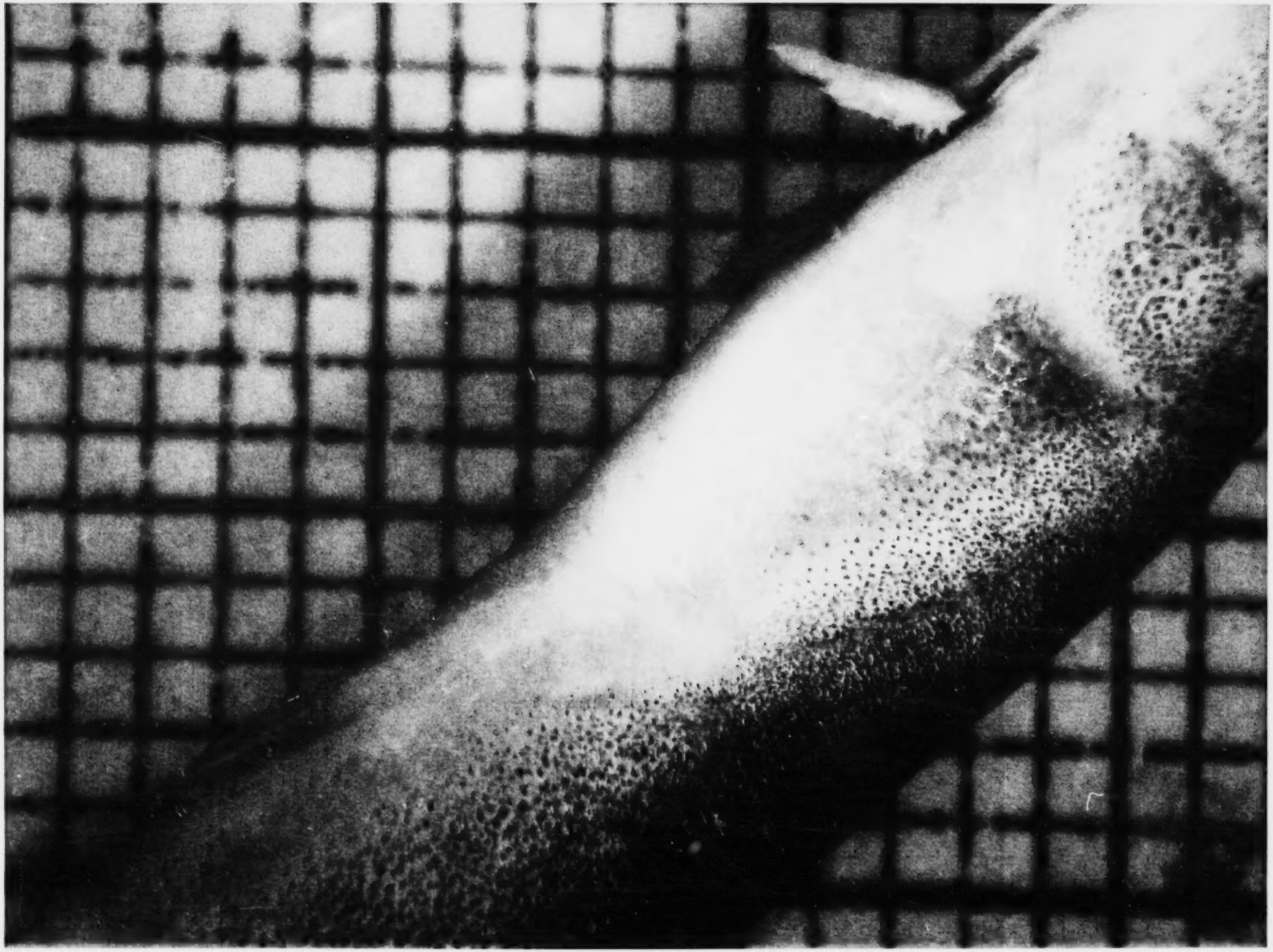












clemensi

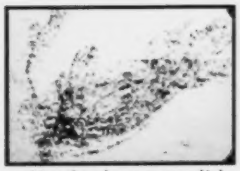
a copepodid hooks.jpg

a copepodid mxp.jpg

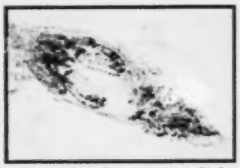
a copepodid ventral.jpg

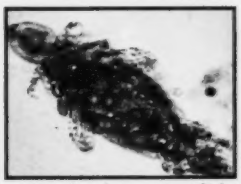
clem copepodid.jpg

attached copepodid lateral.jpg


attached copepodid mxp.jpg

attached copepodid sf.jpg


attached copepodid sternal furca.jpg

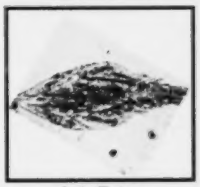

attached copepodid ventral.jpg

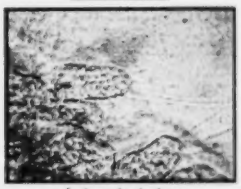
ch1 1.jpg

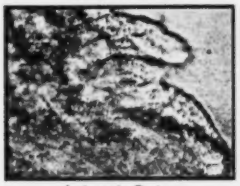
ch1 2.jpg

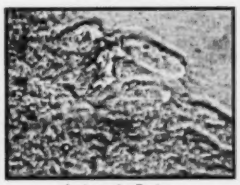
ch1 3.jpg

ch1 4.jpg

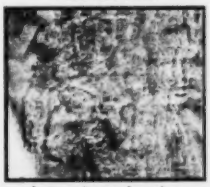

ch1 5.jpg


ch1 p1 1.jpg

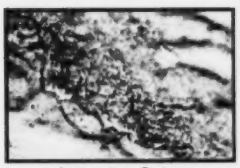

ch1 p1 2.jpg


ch1 p1 3.jpg

ch1 p1 and p2.jpg


ch1 p1 nubs.jpg

ch1 p1 p2 nubs.jpg


ch1 p1 p2.jpg

ch1 p1.jpg

ch1 p2 nubs.jpg

ch1 starting to moult.jpg

ch1 urosome.jpg

clemensi

ch2 1.jpg

ch2 2.jpg

ch2 3.jpg

ch2 b mouthparts.jpg

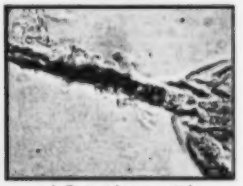
ch2 b.jpg

ch2 dark spots.jpg

ch2 filament.jpg

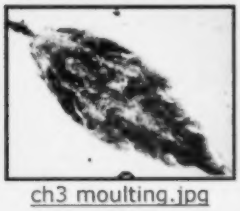
ch2 p1 endopod.jpg

ch2 starting to moult.jpg

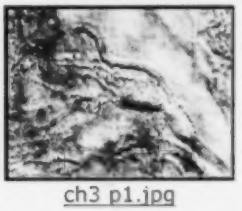

ch2 tether with epizooites.jpg

ch3 1.jpg

ch3 2.jpg


ch3 moulting.jpg

ch3 mouthparts.jpg


ch3 p1.jpg

ch3 tether with epizooites.jpg

ch3 urosome.jpg

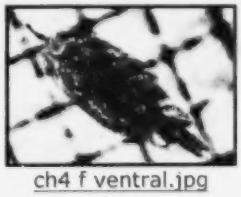
ch4 f 1.jpg

ch4 f 3.jpg

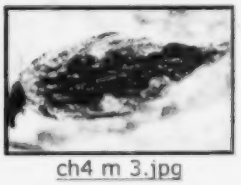
ch4 f lunules.jpg

ch4 f mxp.jpg

ch4 f sf.jpg


ch4 f ventral.jpg

ch4 lunules.jpg


ch4 m 3.jpg

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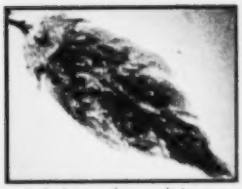
clemensi


ch4 m dorsal.jpg

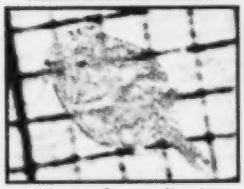
ch4 m ventral.jpg

female and male.jpg

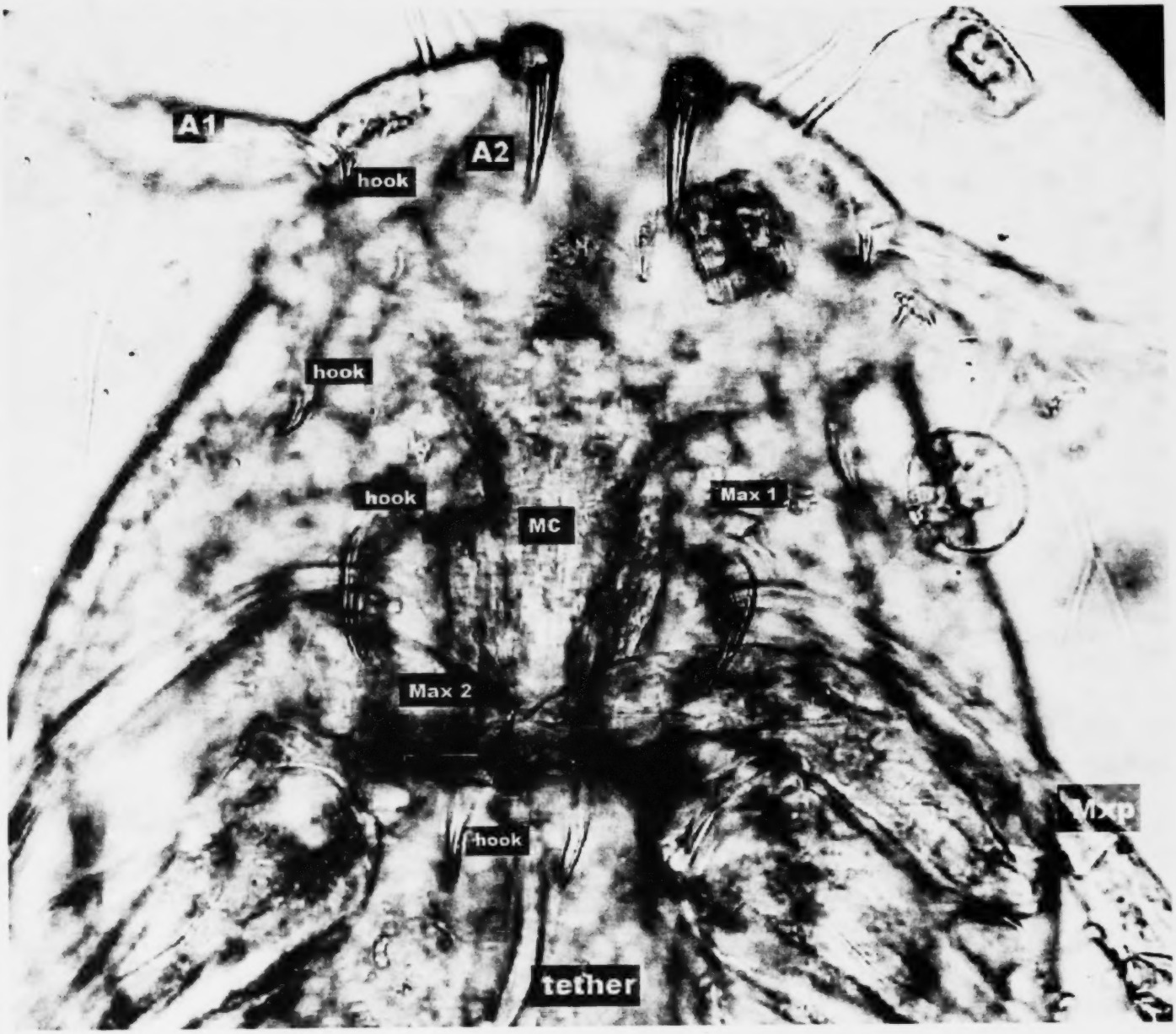
female in ethanol.jpg

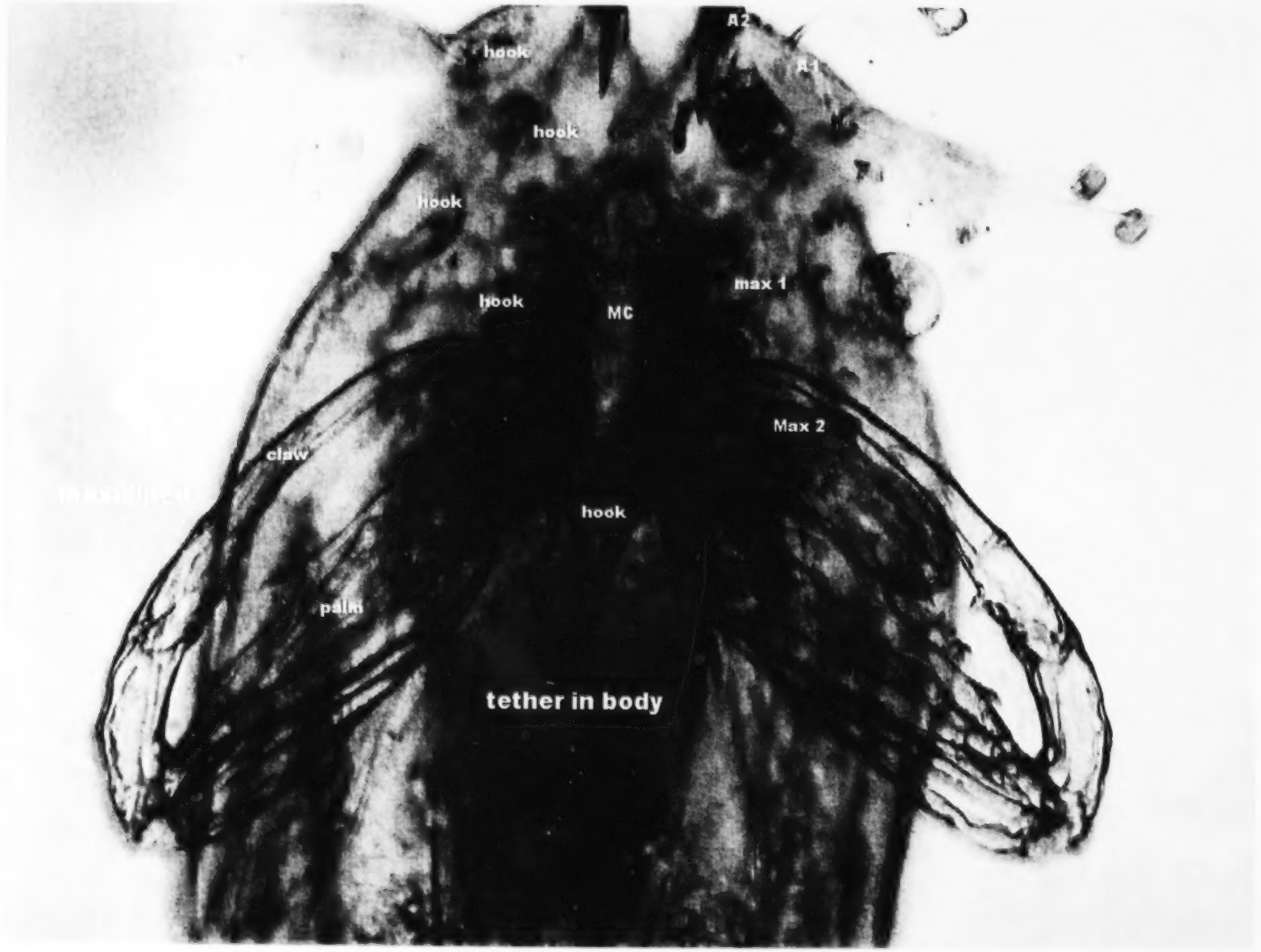
female in formalin.jpg

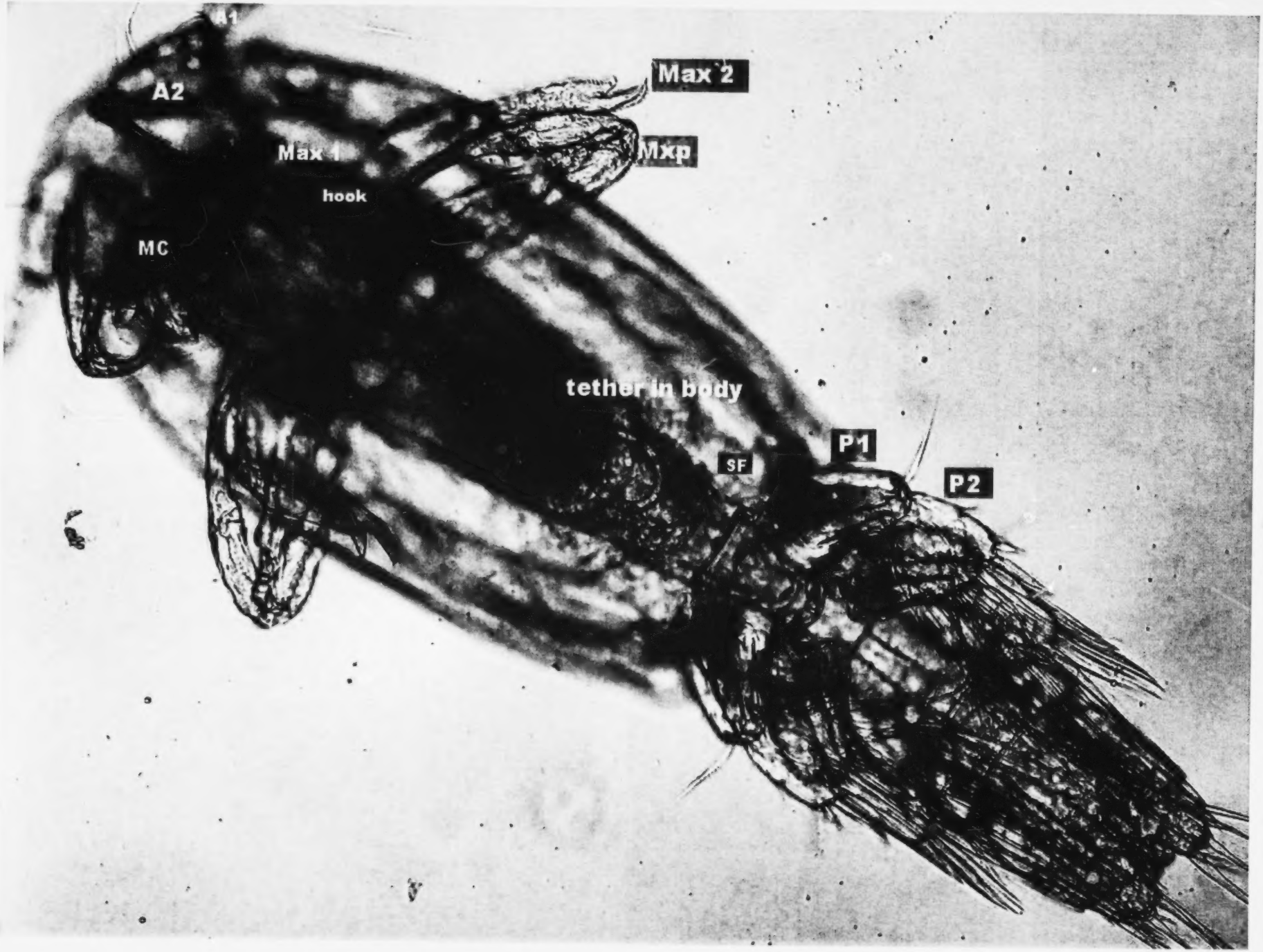
group ethanol.jpg


male in formalin.jpg

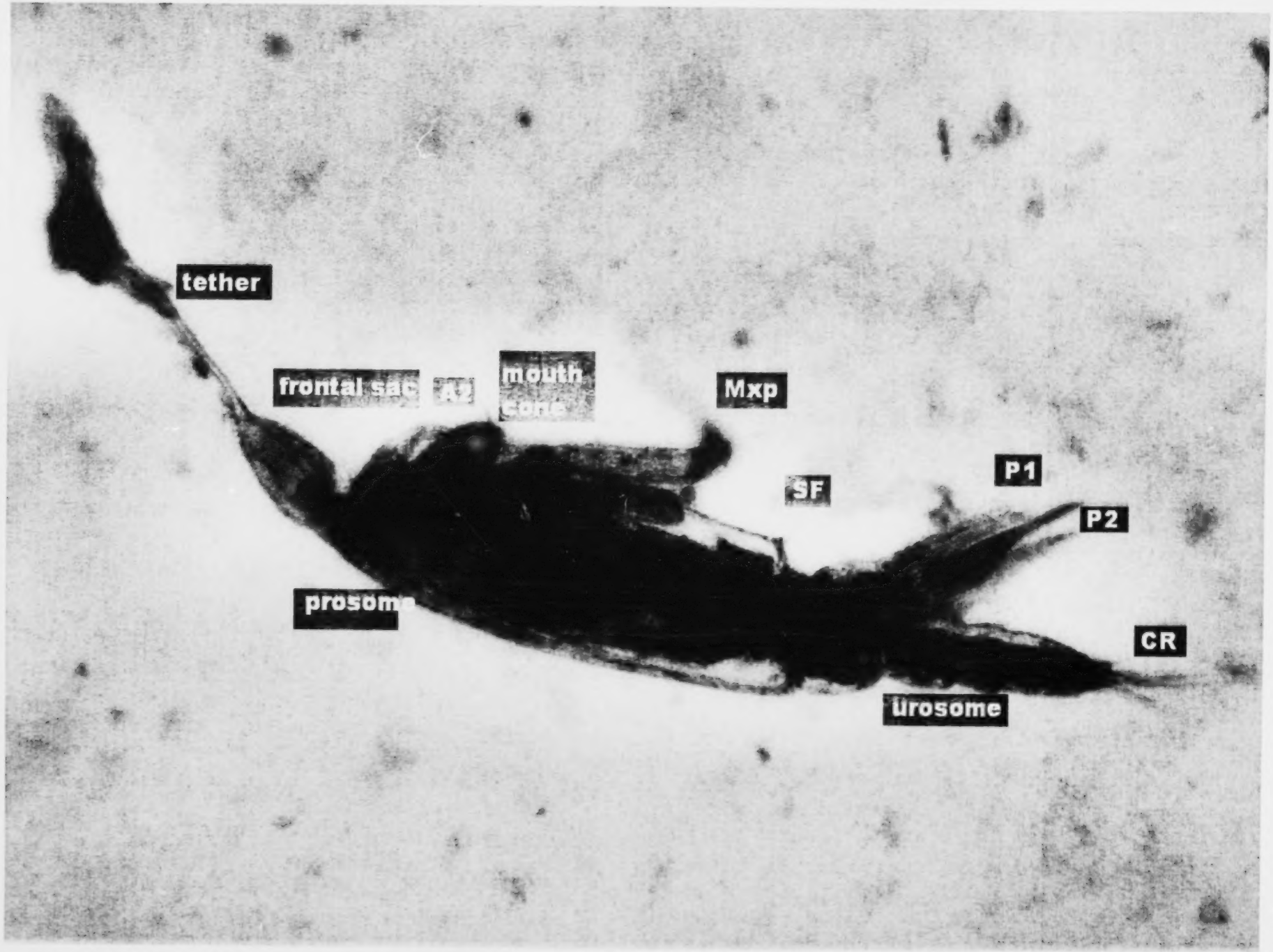
male lunule.jpg

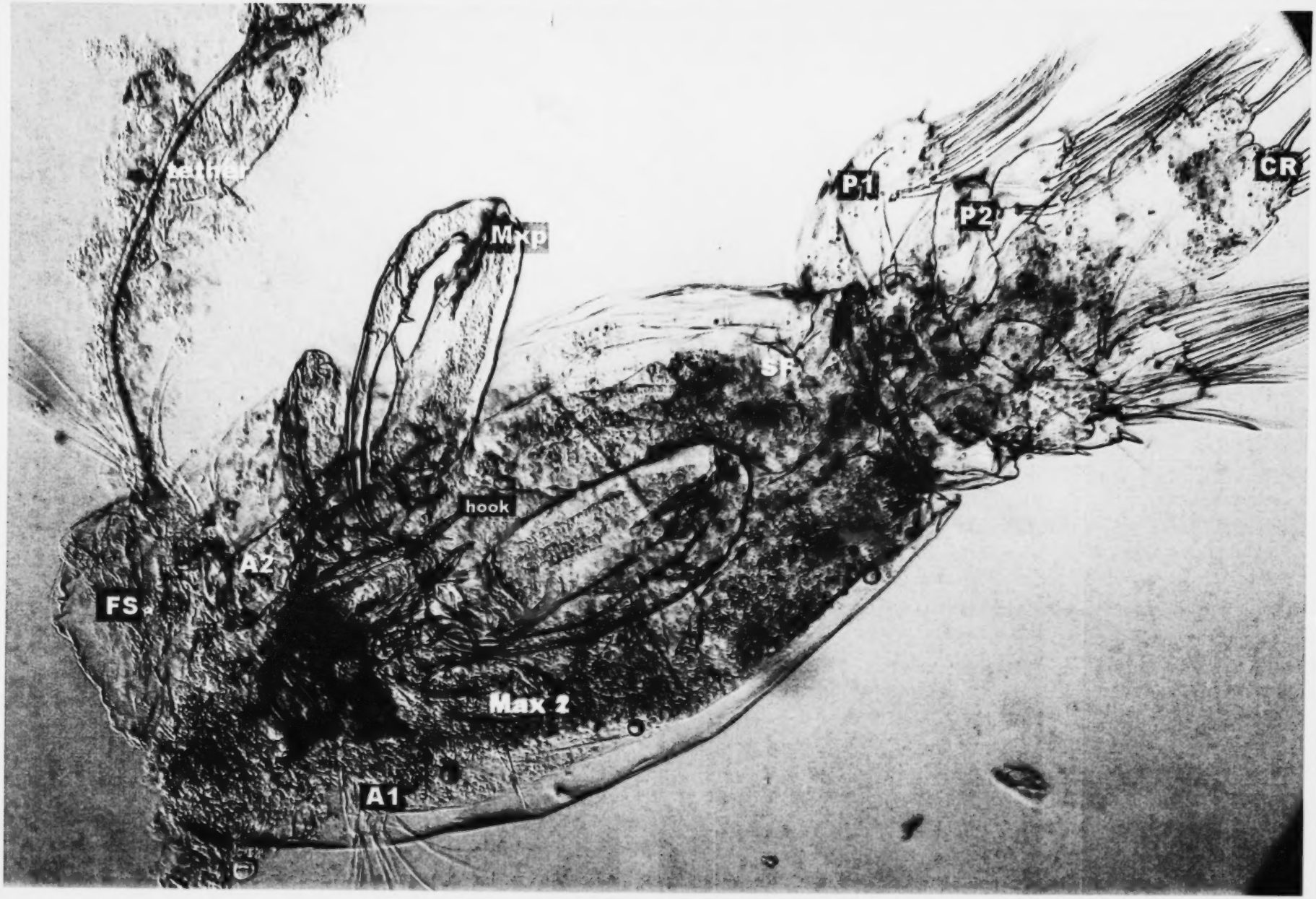

A1
A2
hook
hook
hook
MC
Max 1
Max 2
hook
tether


A2
A1
hook
hook
hook
hook
max 1
MC
Max 2
claw
hook
palp
tether in body

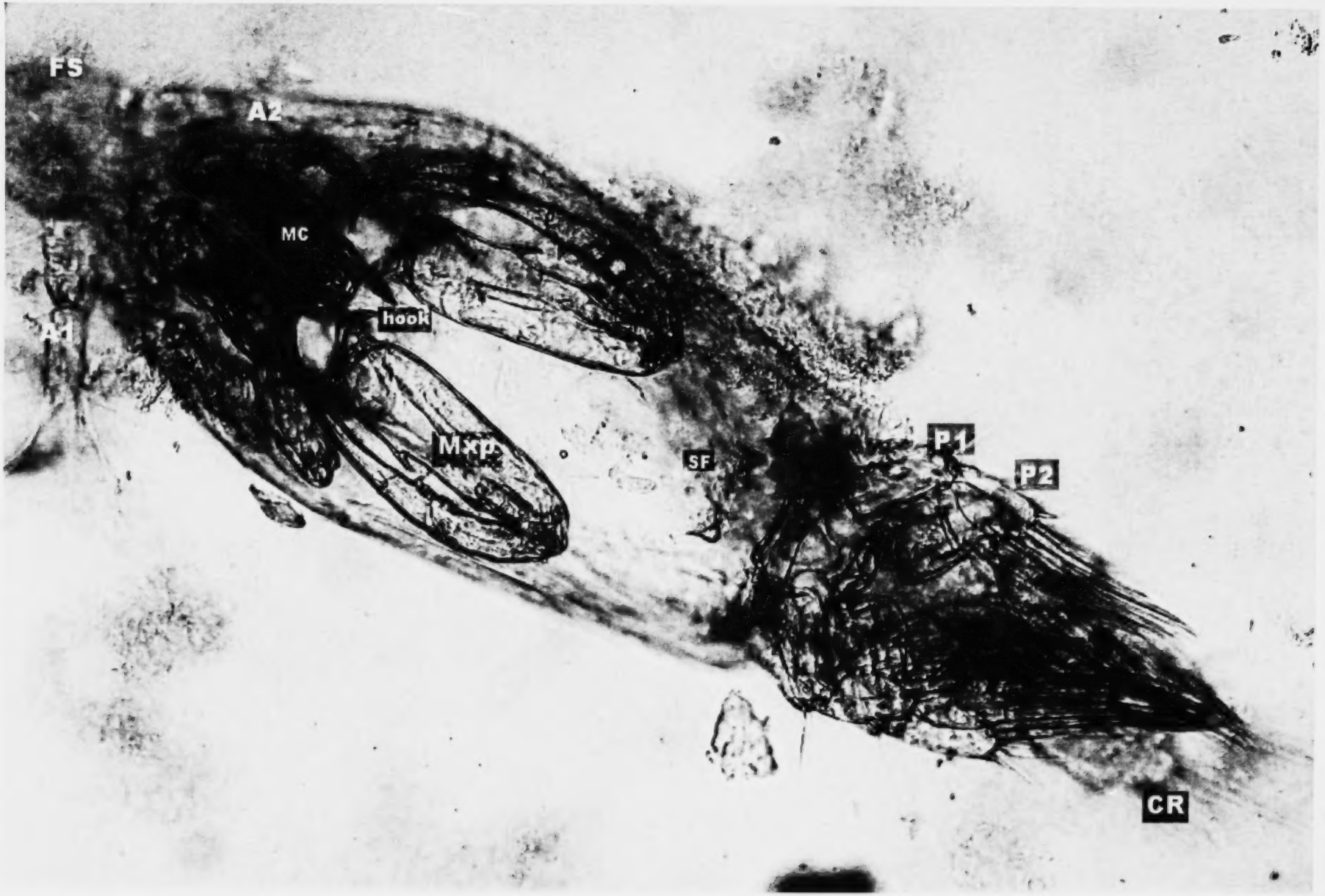

A1
A2
Max 2
Max 1
Mxp
hook
MC
tether in body
SF
P1
P2

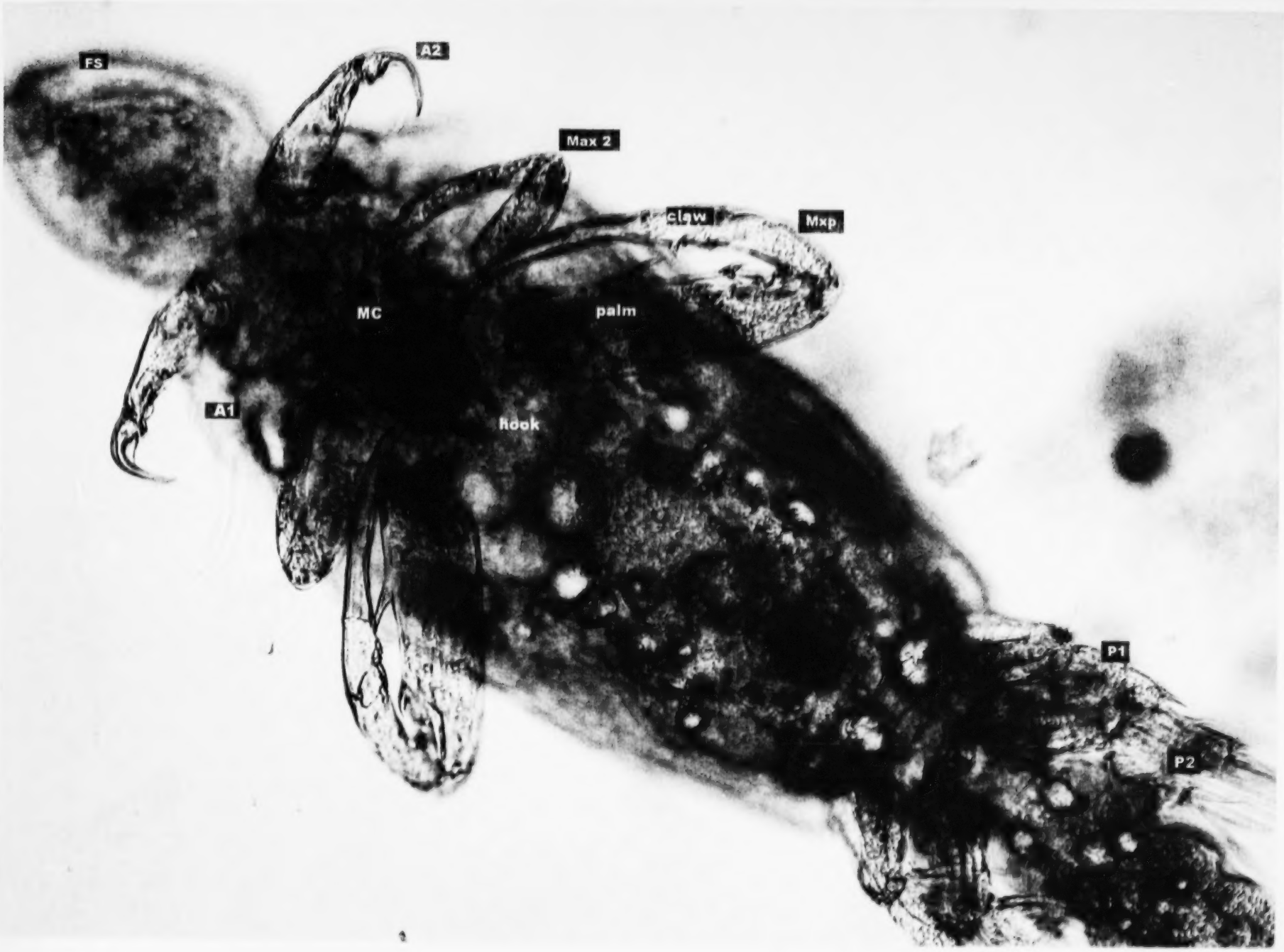
SF

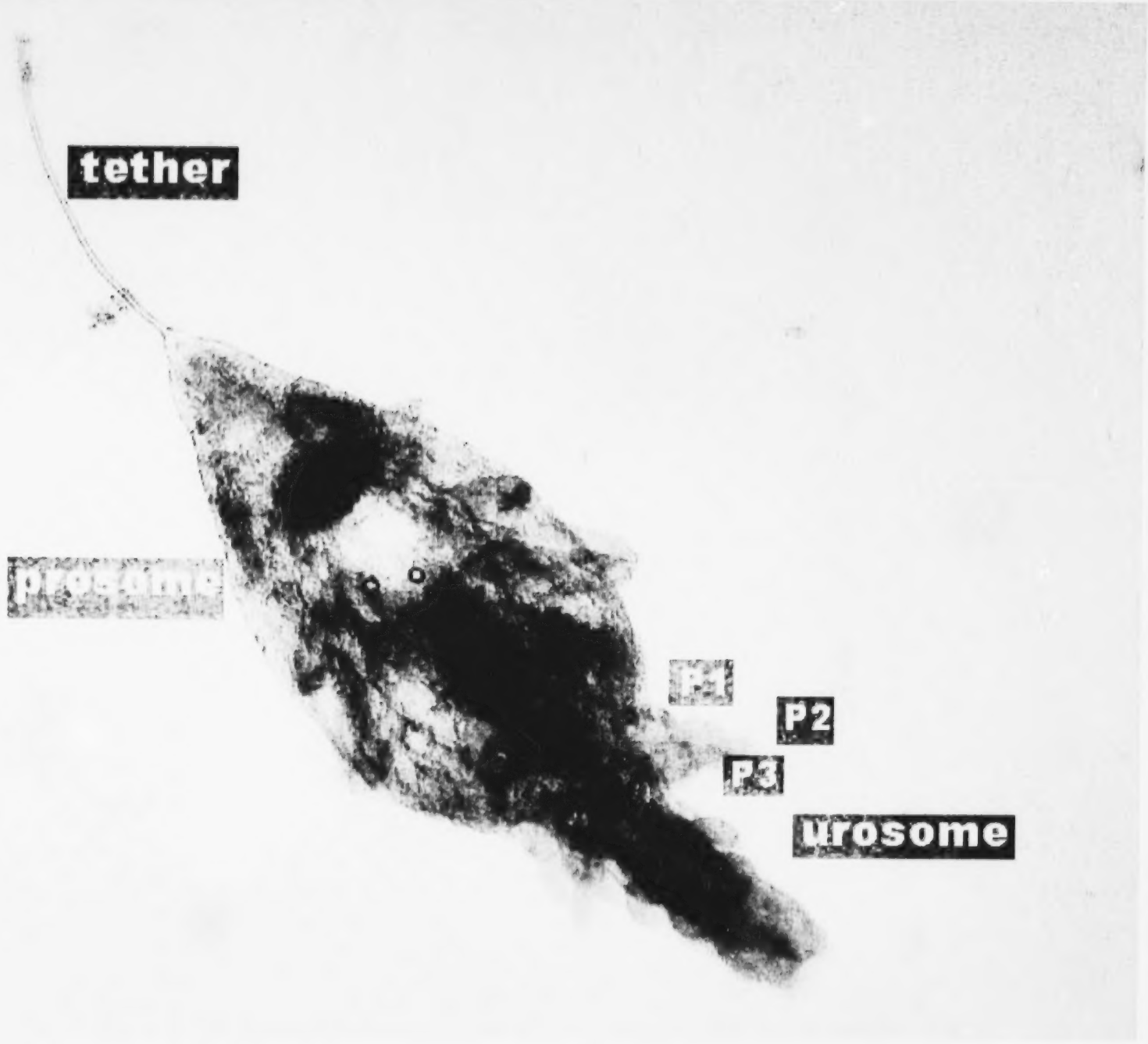

tether
frontal sac
A1
mouth cone
Mxp
SF
P1
P2
prosoma
CR
urosome

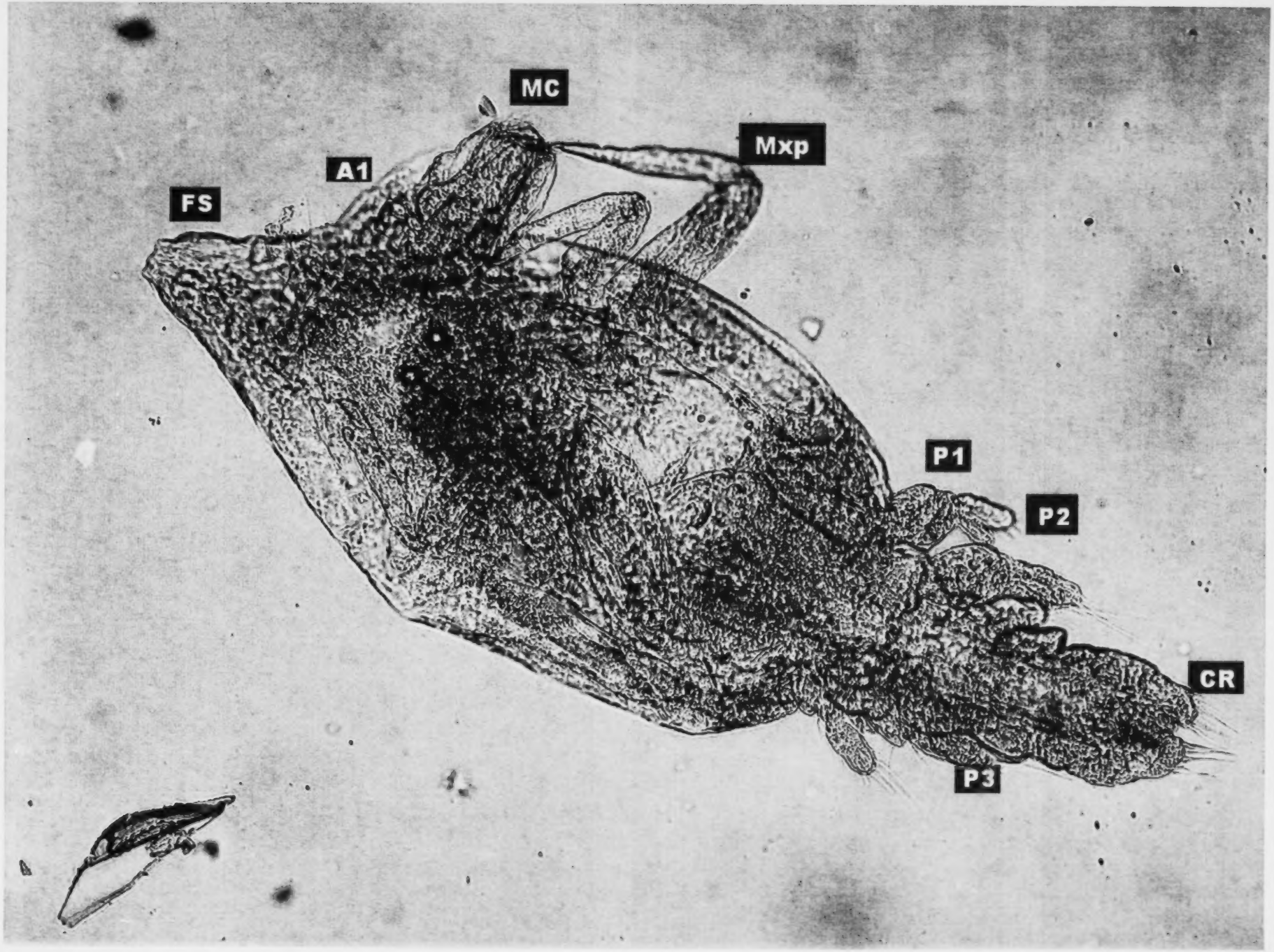

antenna
MxP
P1
P2
CR
SP
hook
A2
FS
Max 2
A1

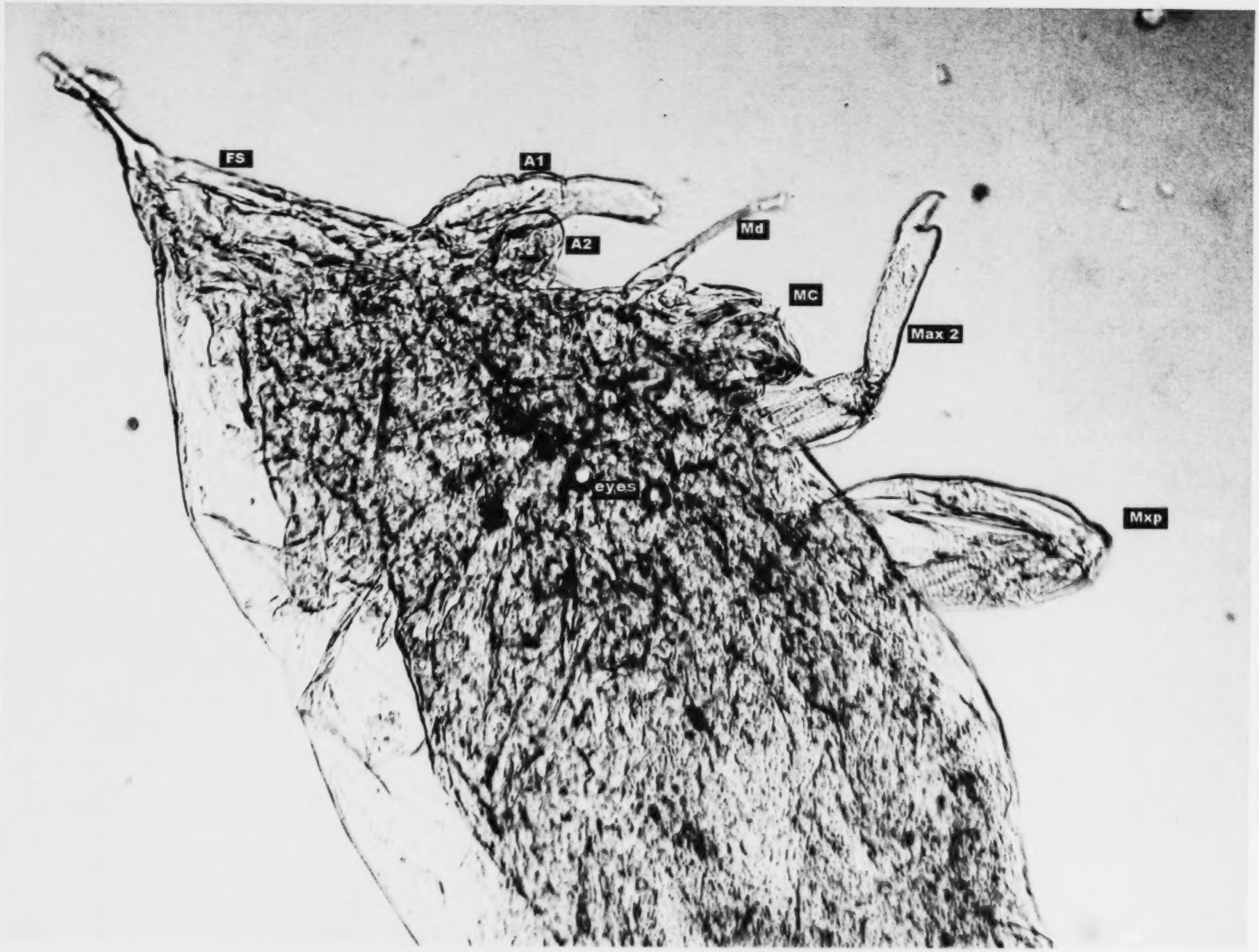
P1 ex
en
P1 B
SE

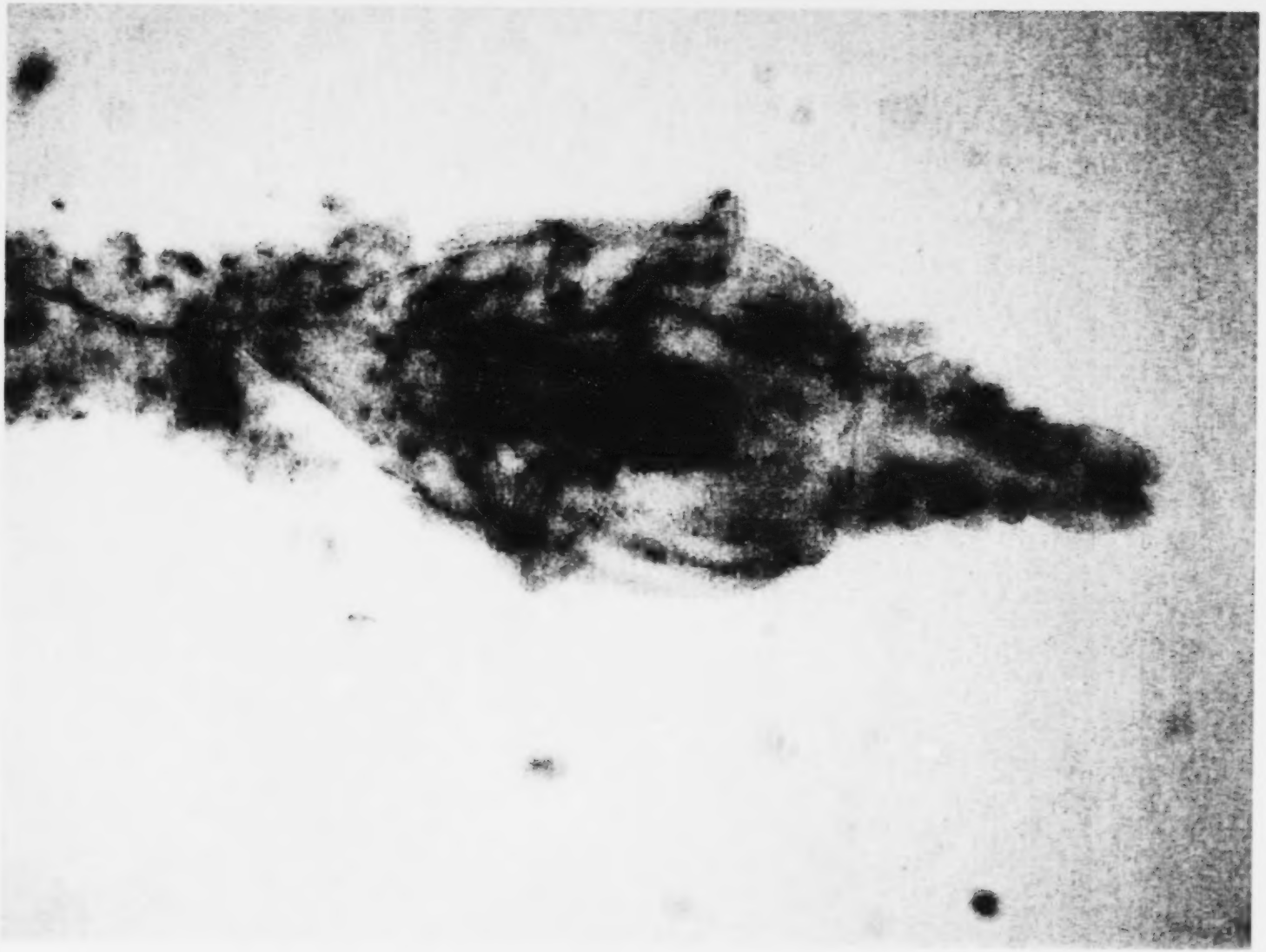

FS
A2
MC
hook
A1
Mxp
SF
P1
P2
CR

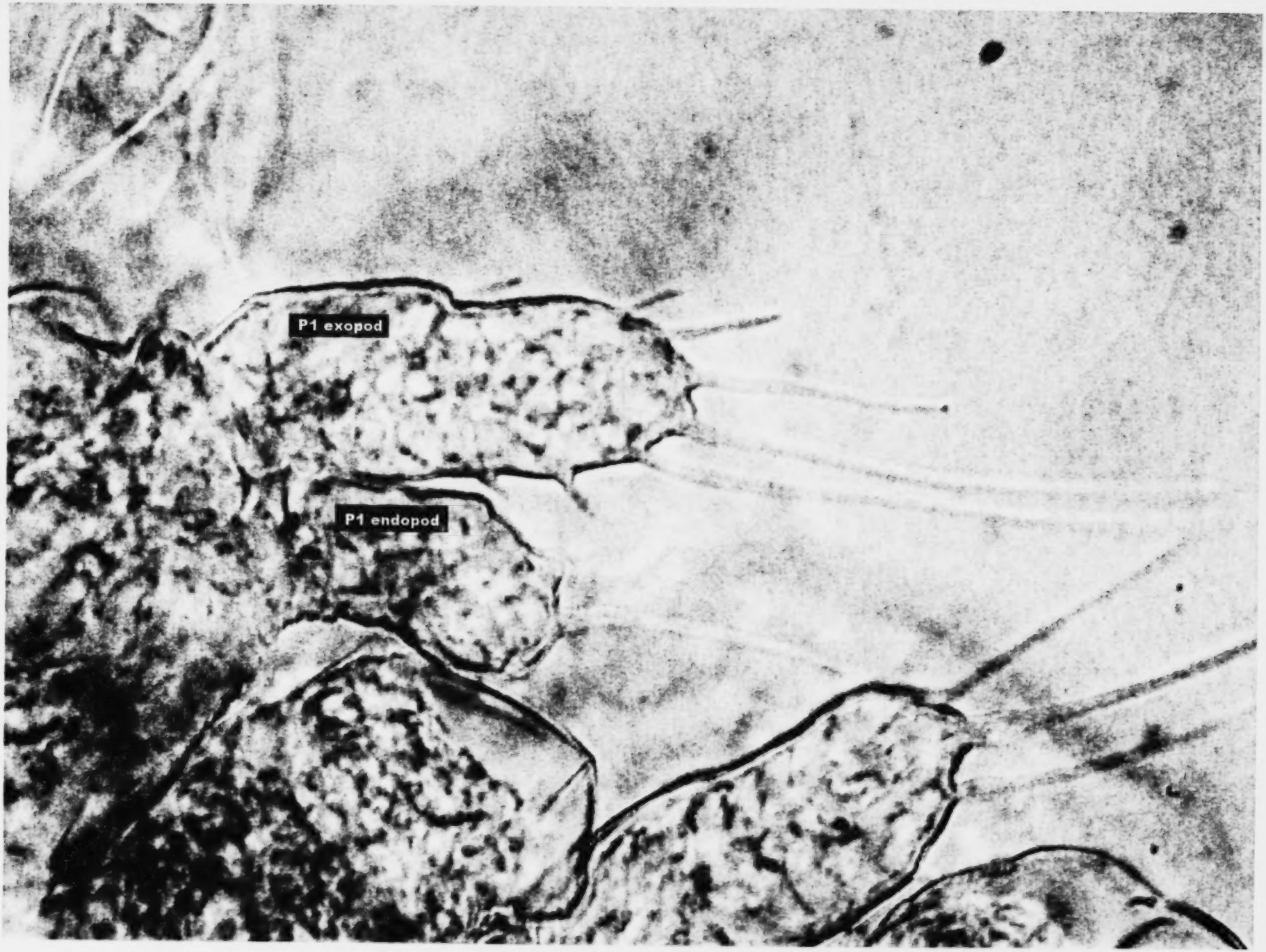

FS
A2
Max 2
claw
Mxp
MC
palm
A1
hook
P1
P2

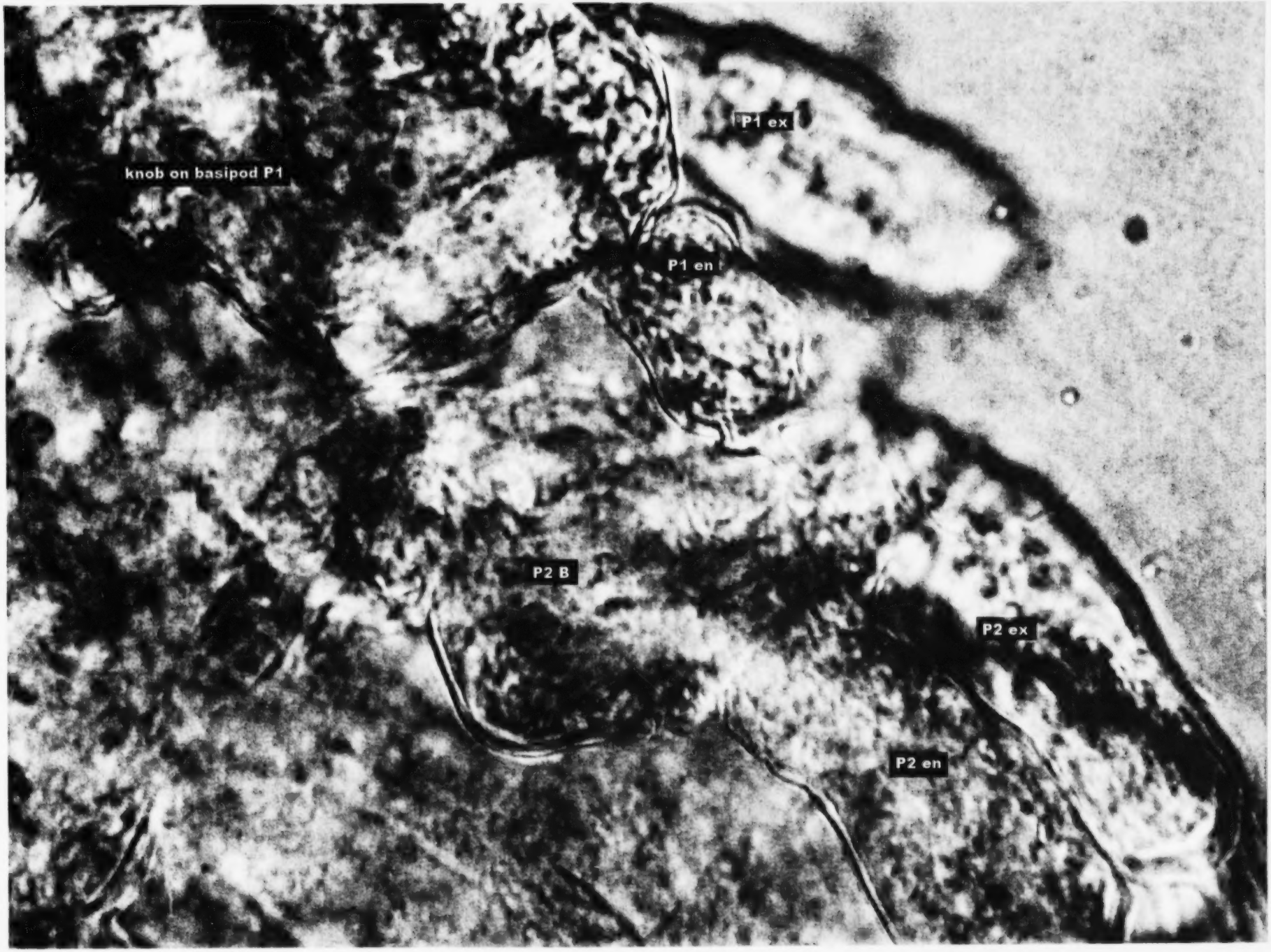

tether
P1
P2
P3
urosome

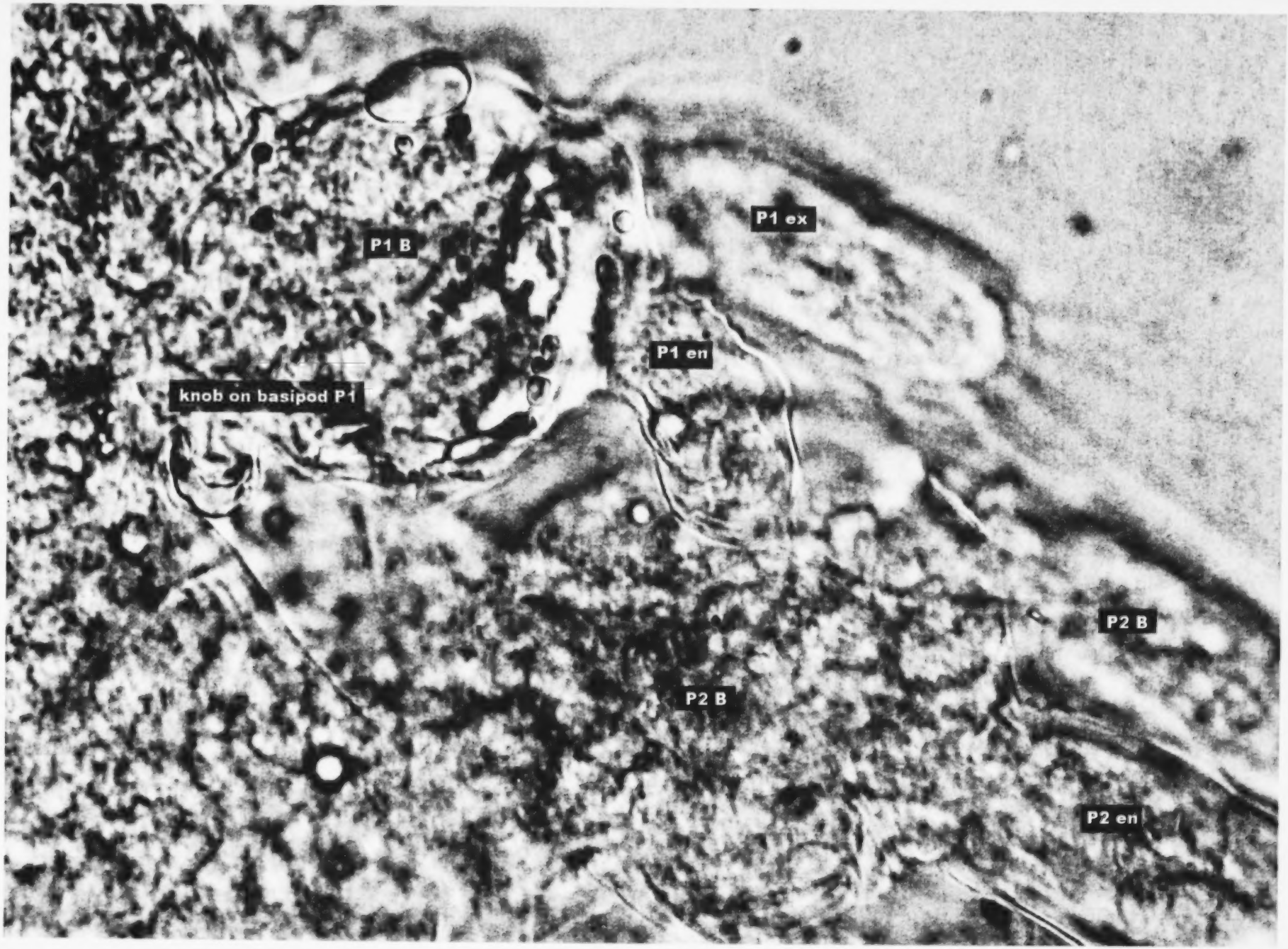

MC
Mxp
A1
FS
P1
P2
CR
P3

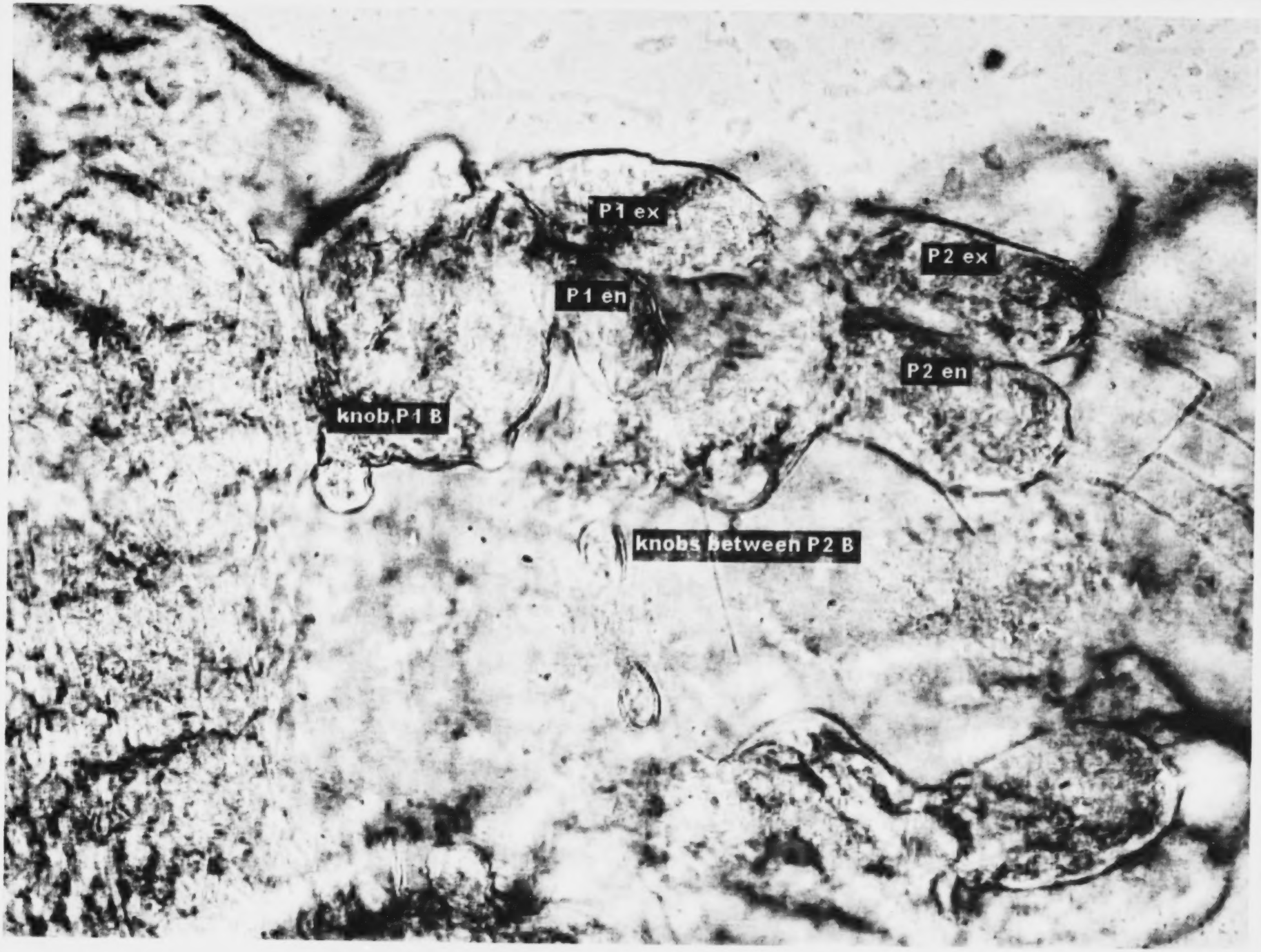

FS
A1
A2
Md
MC
Max 2
eyes
Mxp




P1 exopod
P1 endopod

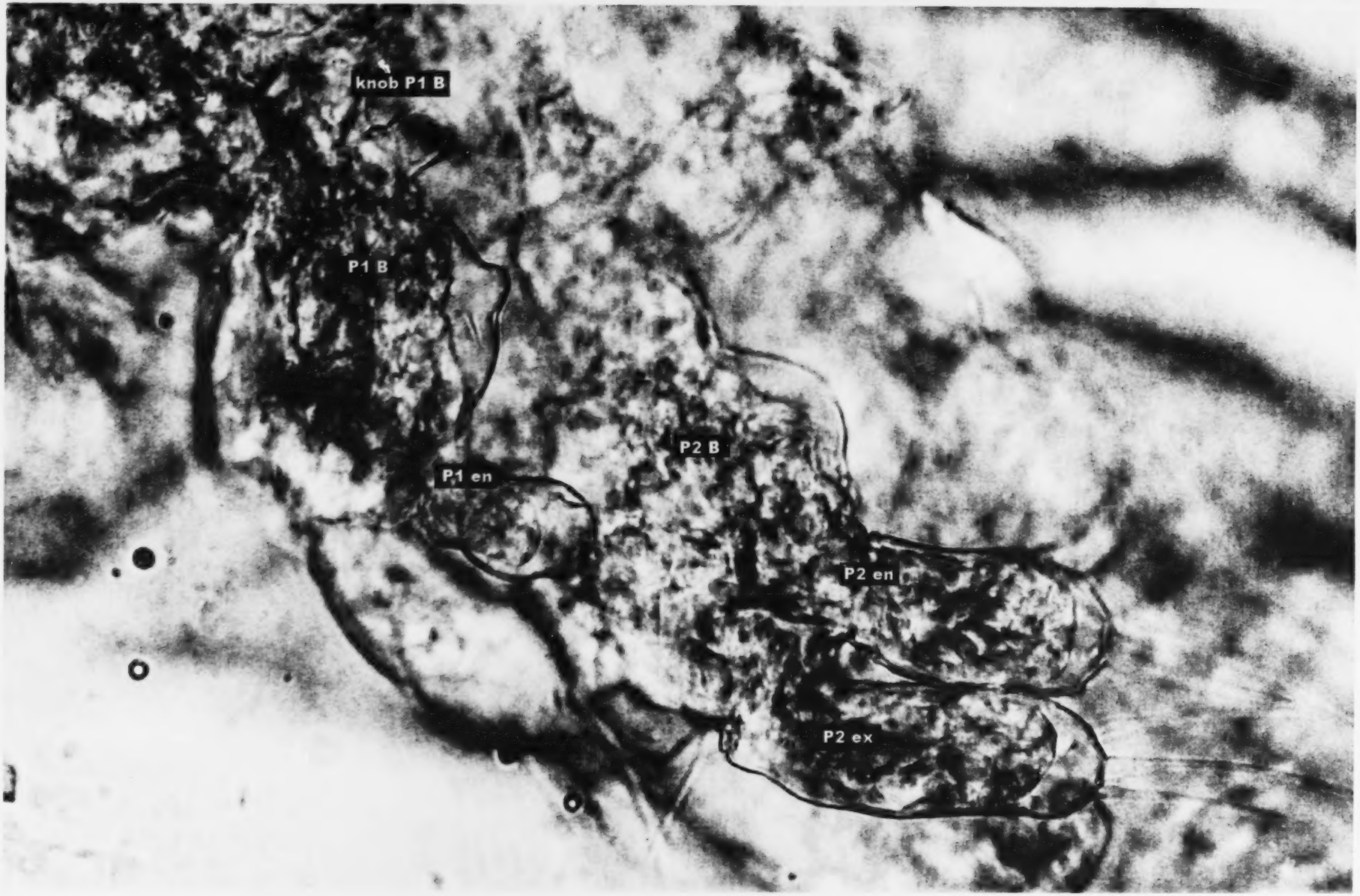

knob on basipod P1
P1 ex
P1 en
P2 B
P2 ex
P2 en

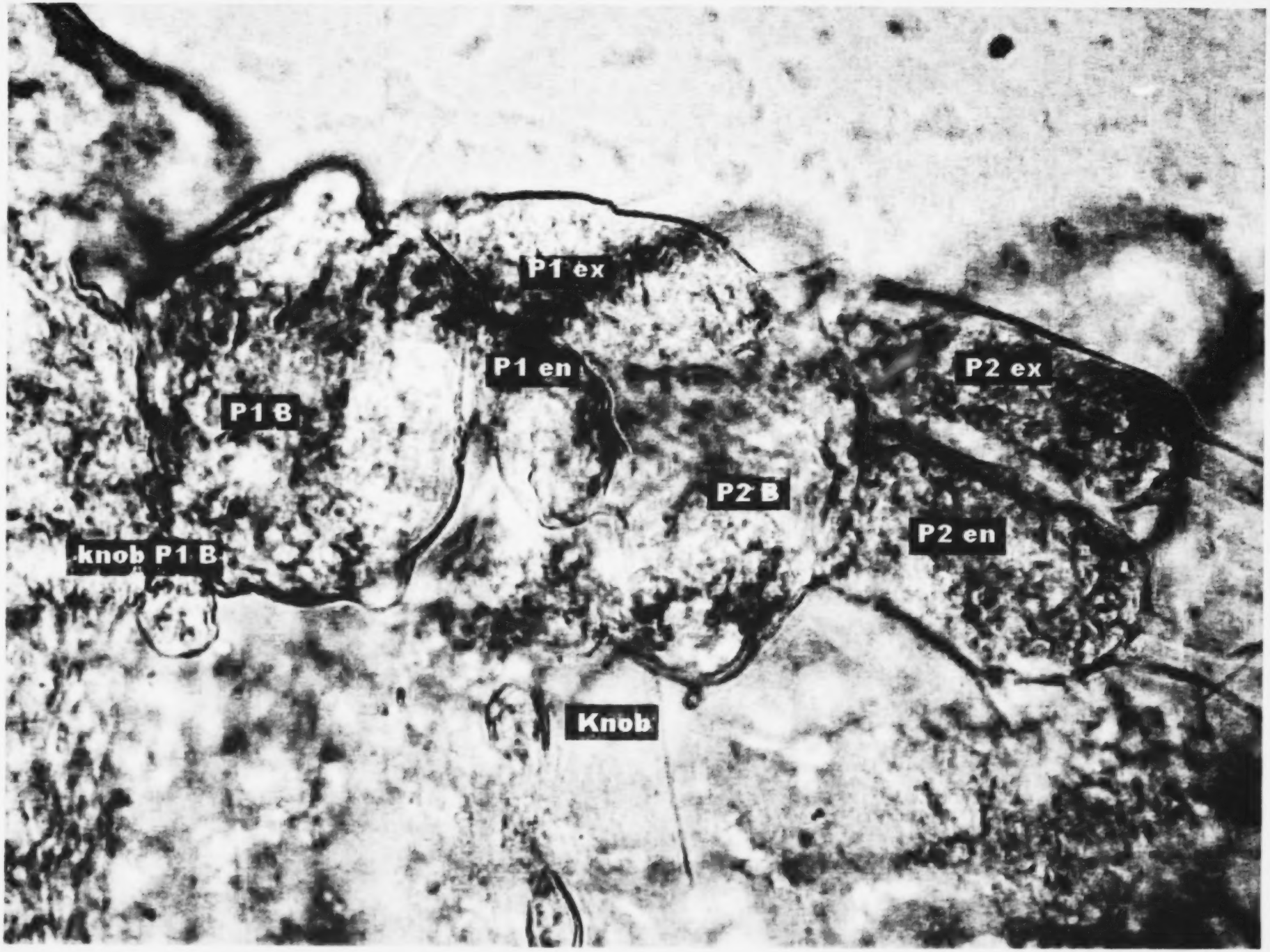

P1 B
P1 ex
P1 en
knob on basipod P1
P2 B
P2 B
P2 en

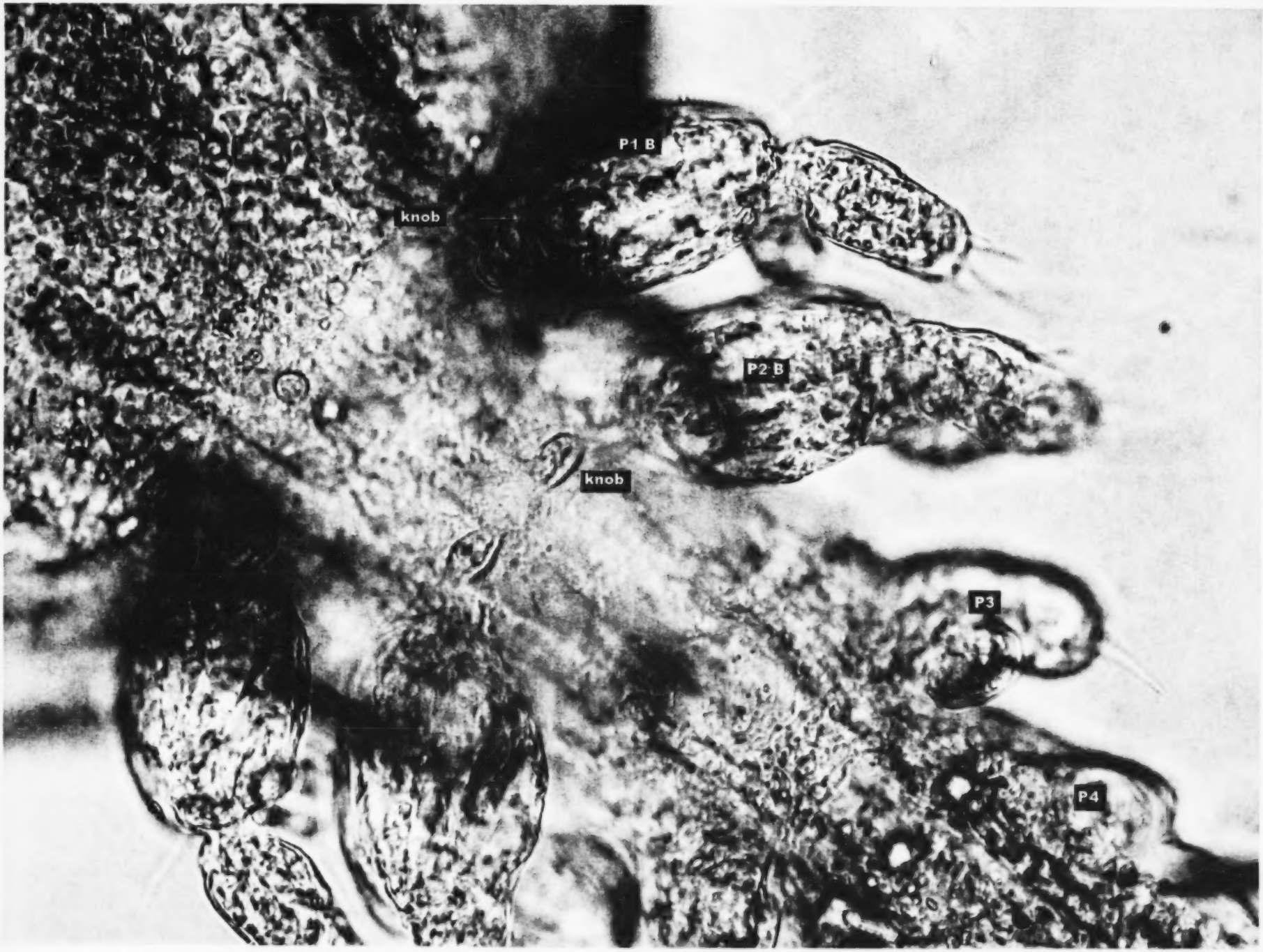

P1 ex
P2 ex
P1 en
P2 en
knob P1 B
knobs between P2 B

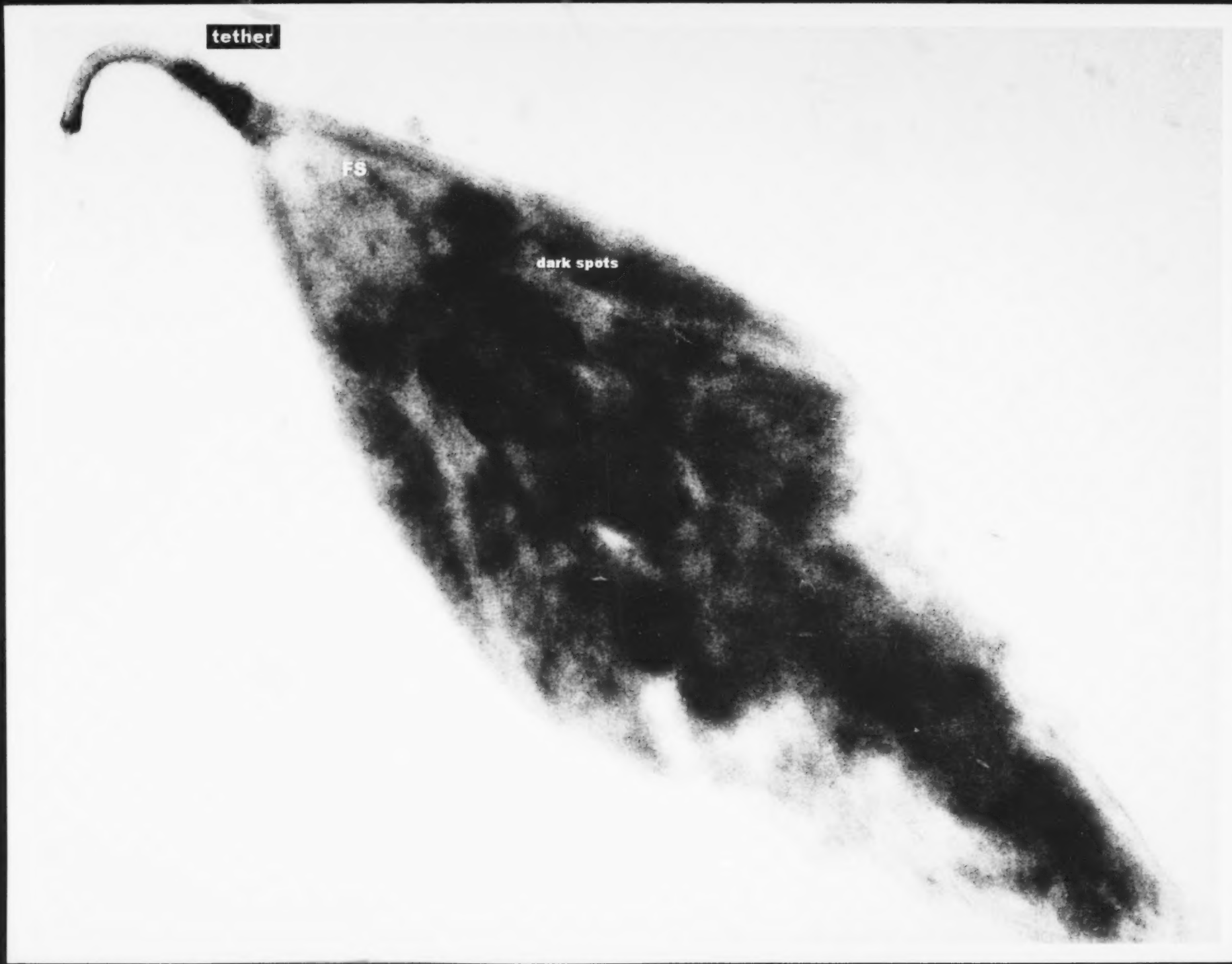
knob on P1 B
P1 B
knob
P1 ei
P1 ex
P2 B

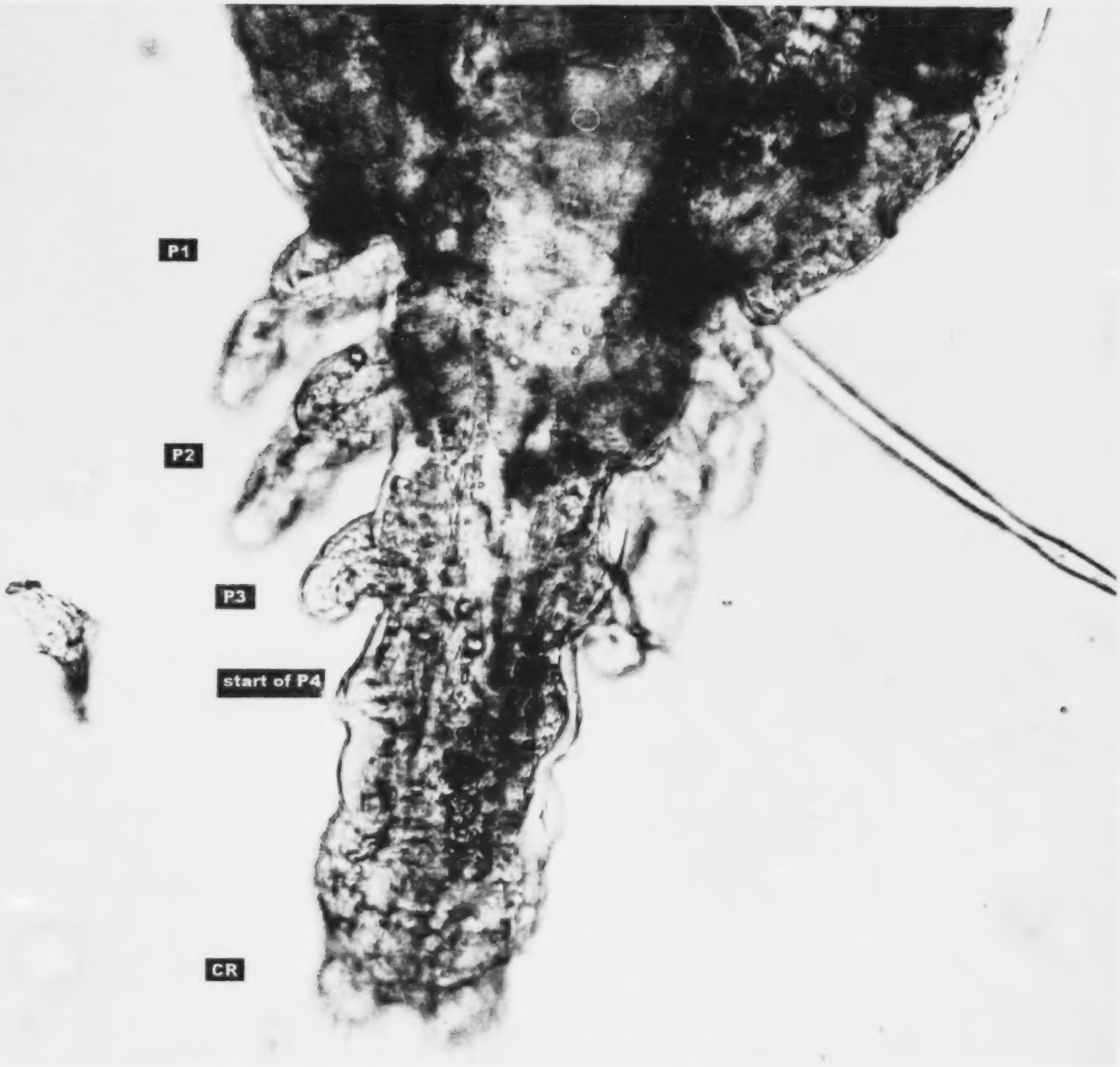
knob P1 B
P1 B
knob
P1 en
P1 ex
P2 B
P2 en
P2 ex

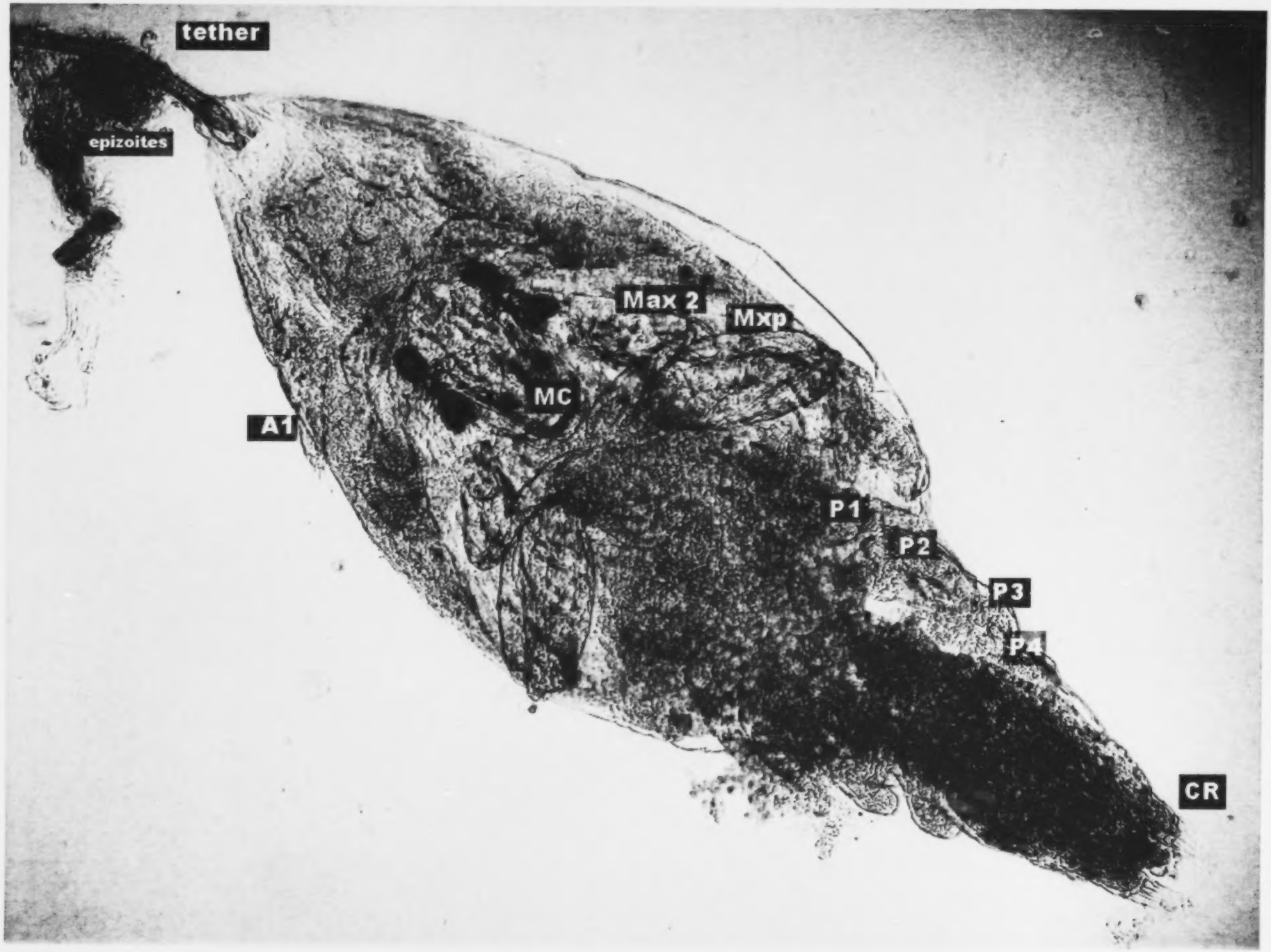

knob P1 B
P1 B
P1 en
P2 B
P2 en
P2 ex

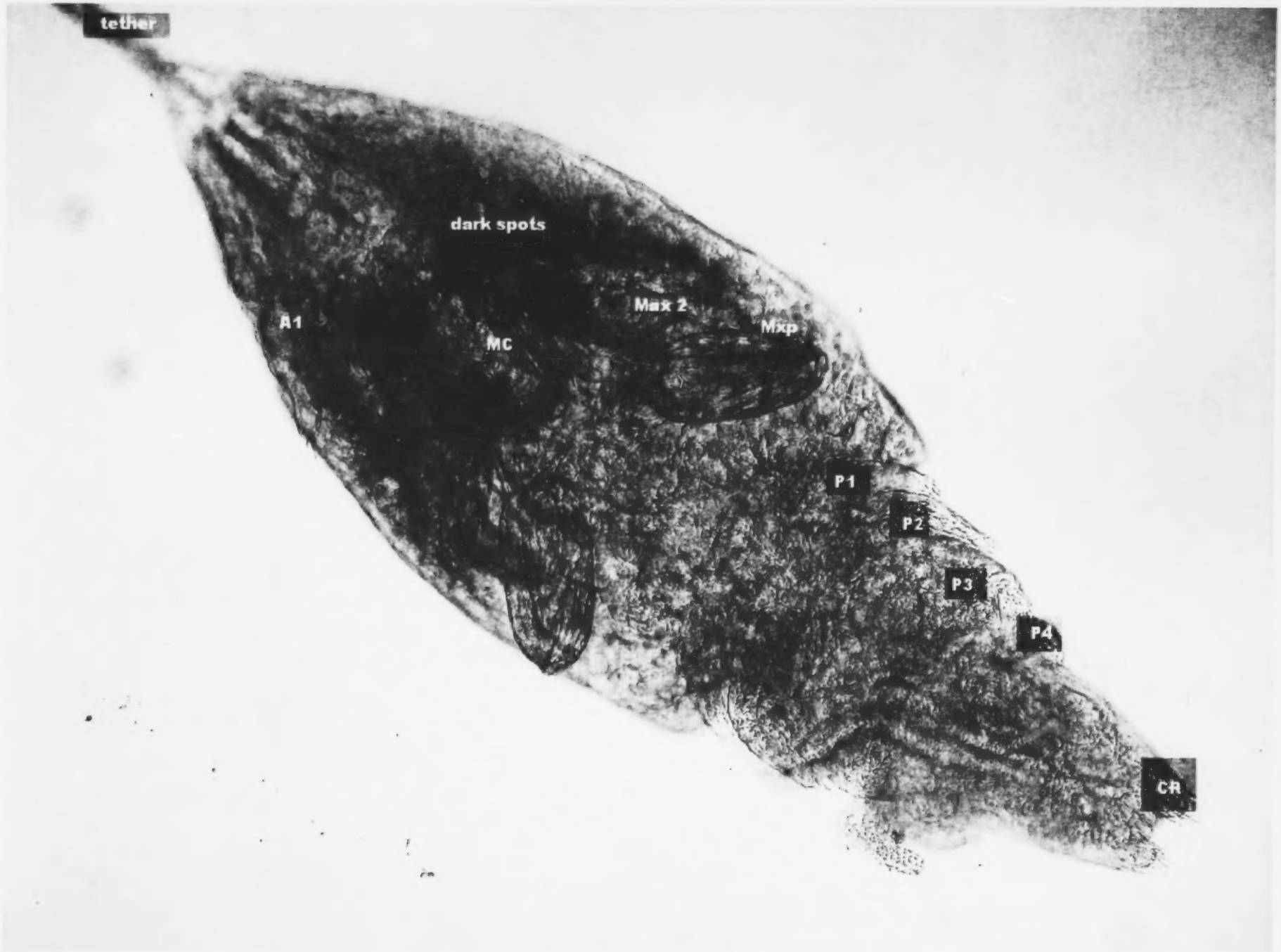

P1 ex
P1 en
P1 B
P2 ex
P2 B
P2 en
knob P1 B
Knob

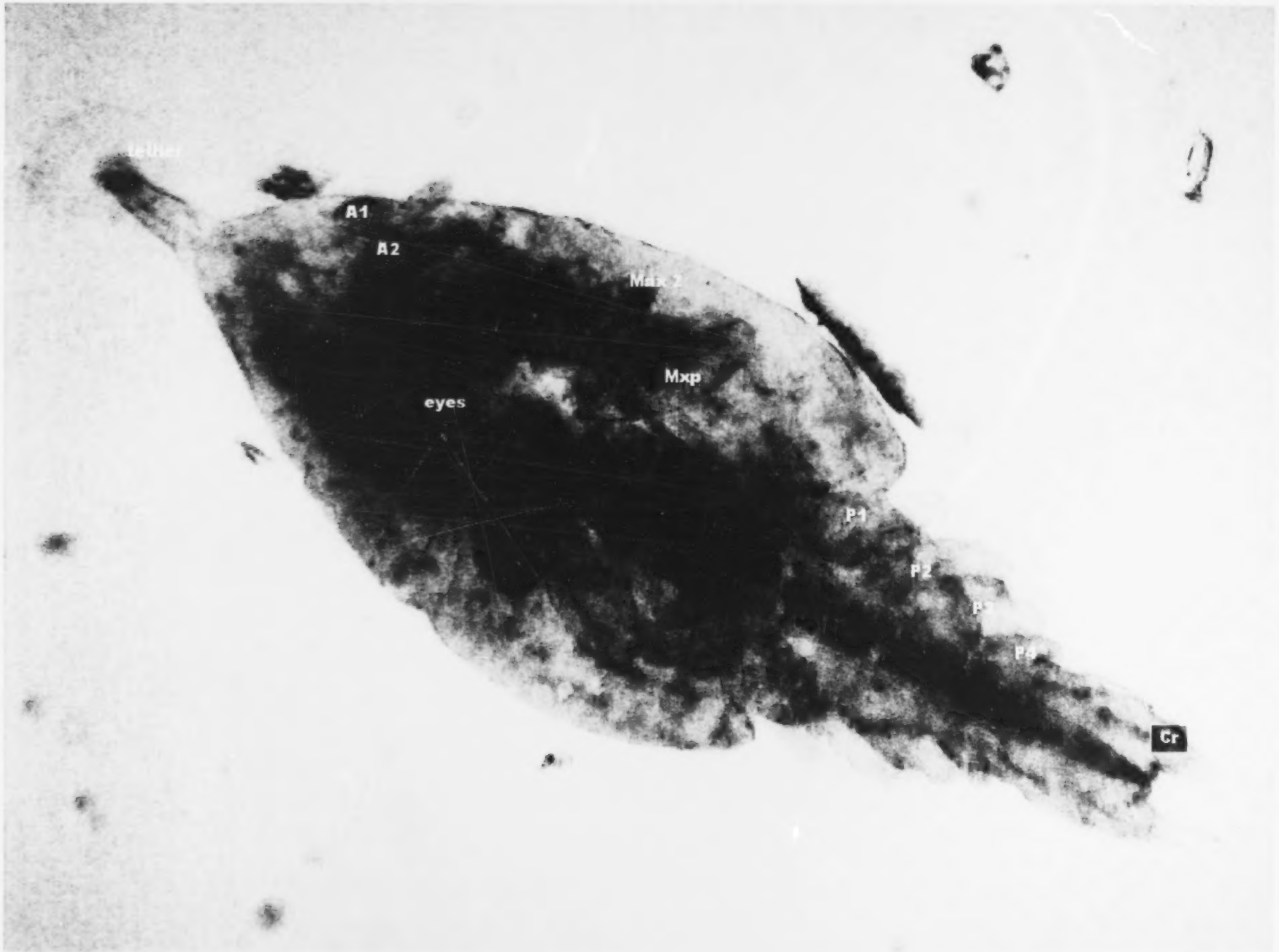

P1 B
knob
P2 B
knob
P3
P4


tether
FS
dark spots

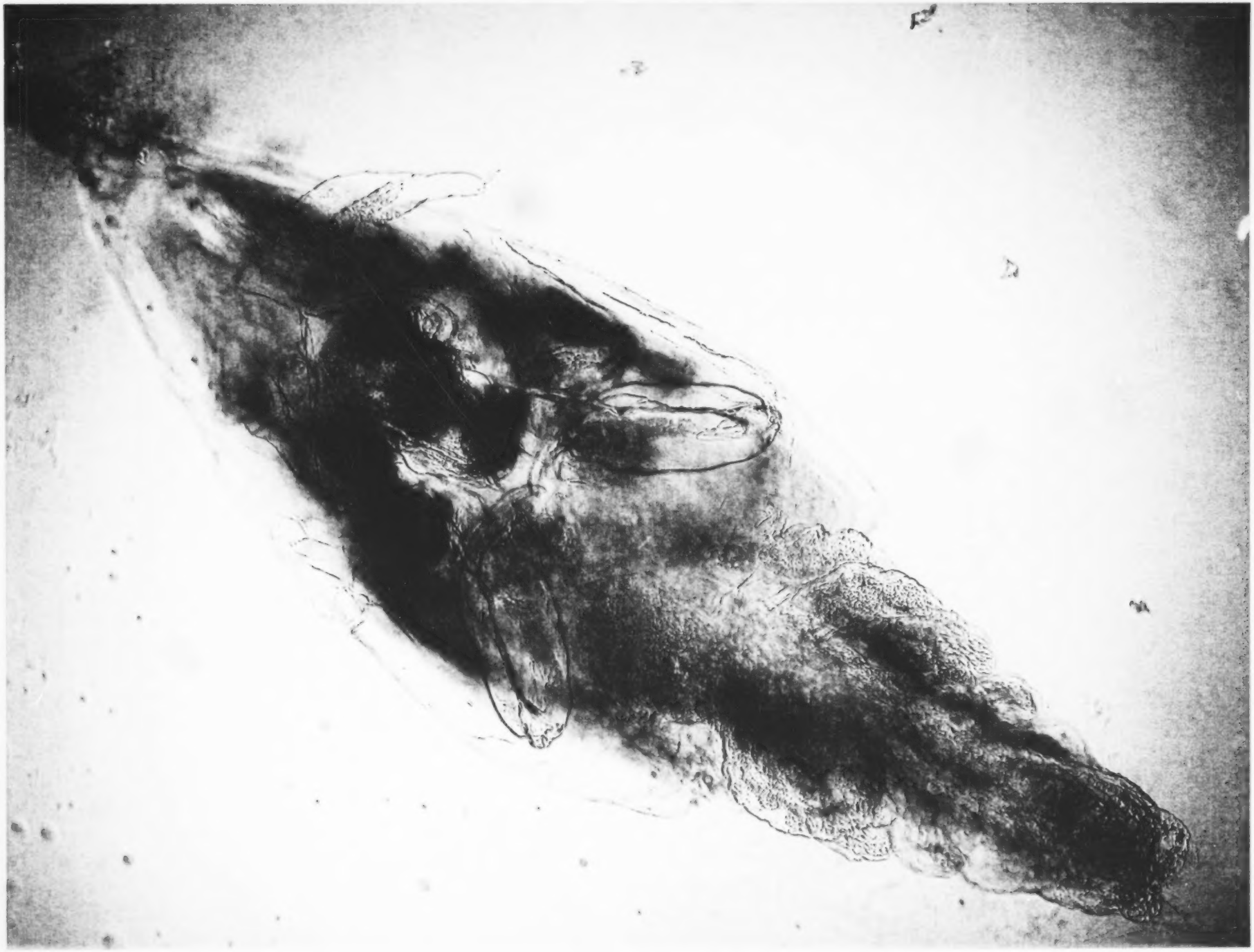

P1
P2
P3
start of P4
CR


tether
epizoites
Max 2
Mxp
MC
A1
P1
P2
P3
P4
CR

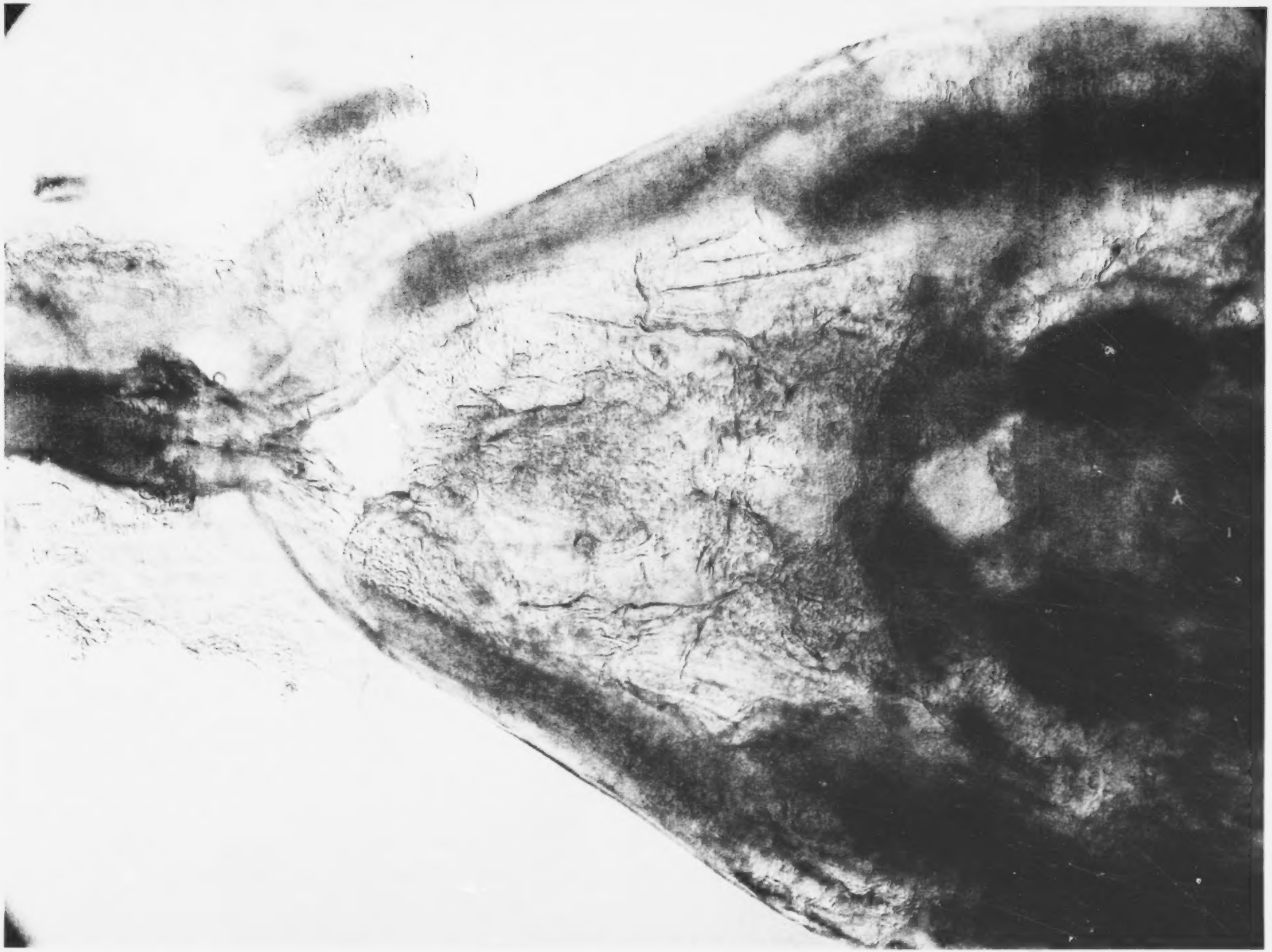

tether
dark spots
A1
MC
Max 2
Mxp
P1
P2
P3
P4
CR

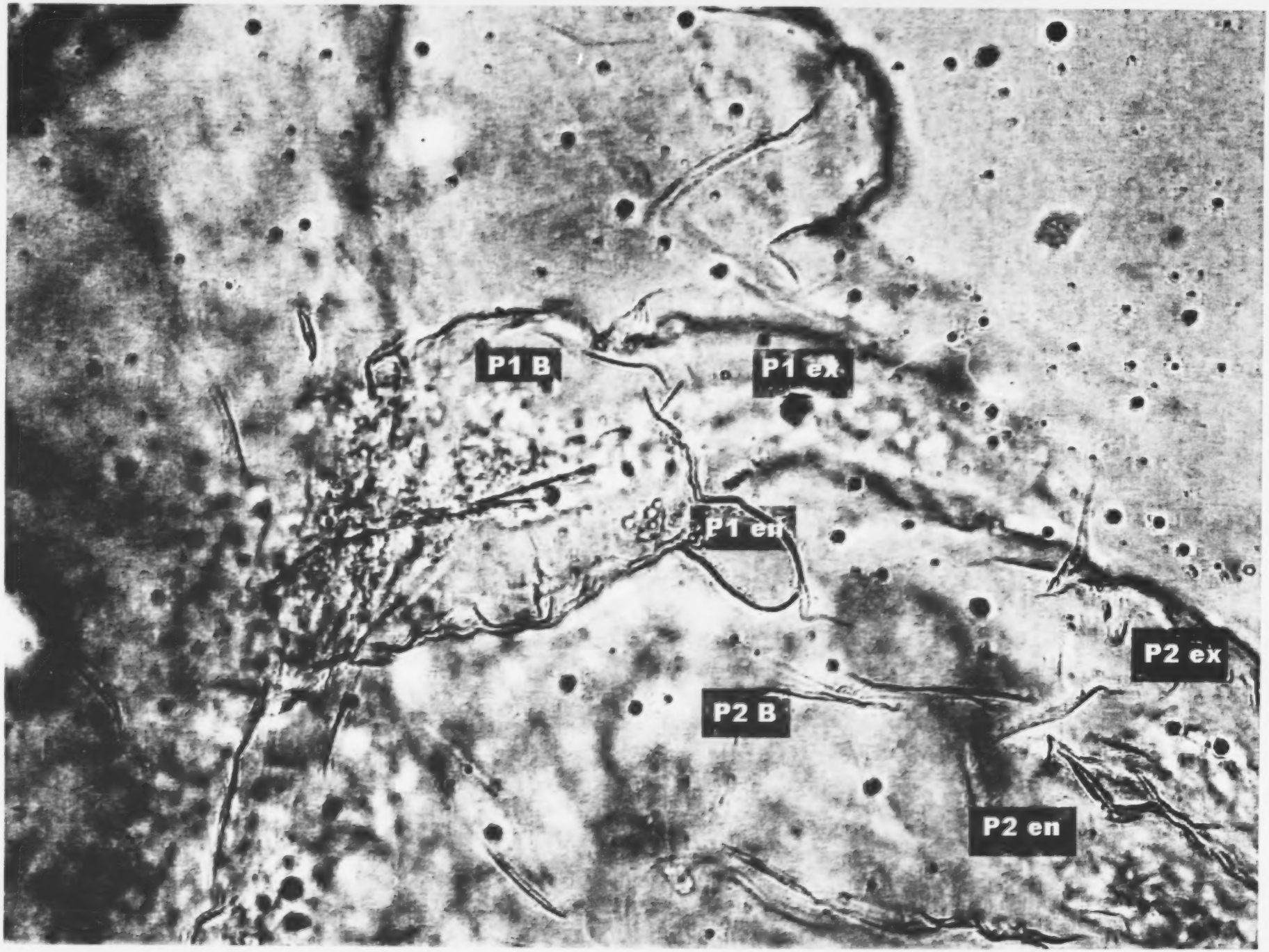

A1
A2
Mxp
eyes
P1
Cr

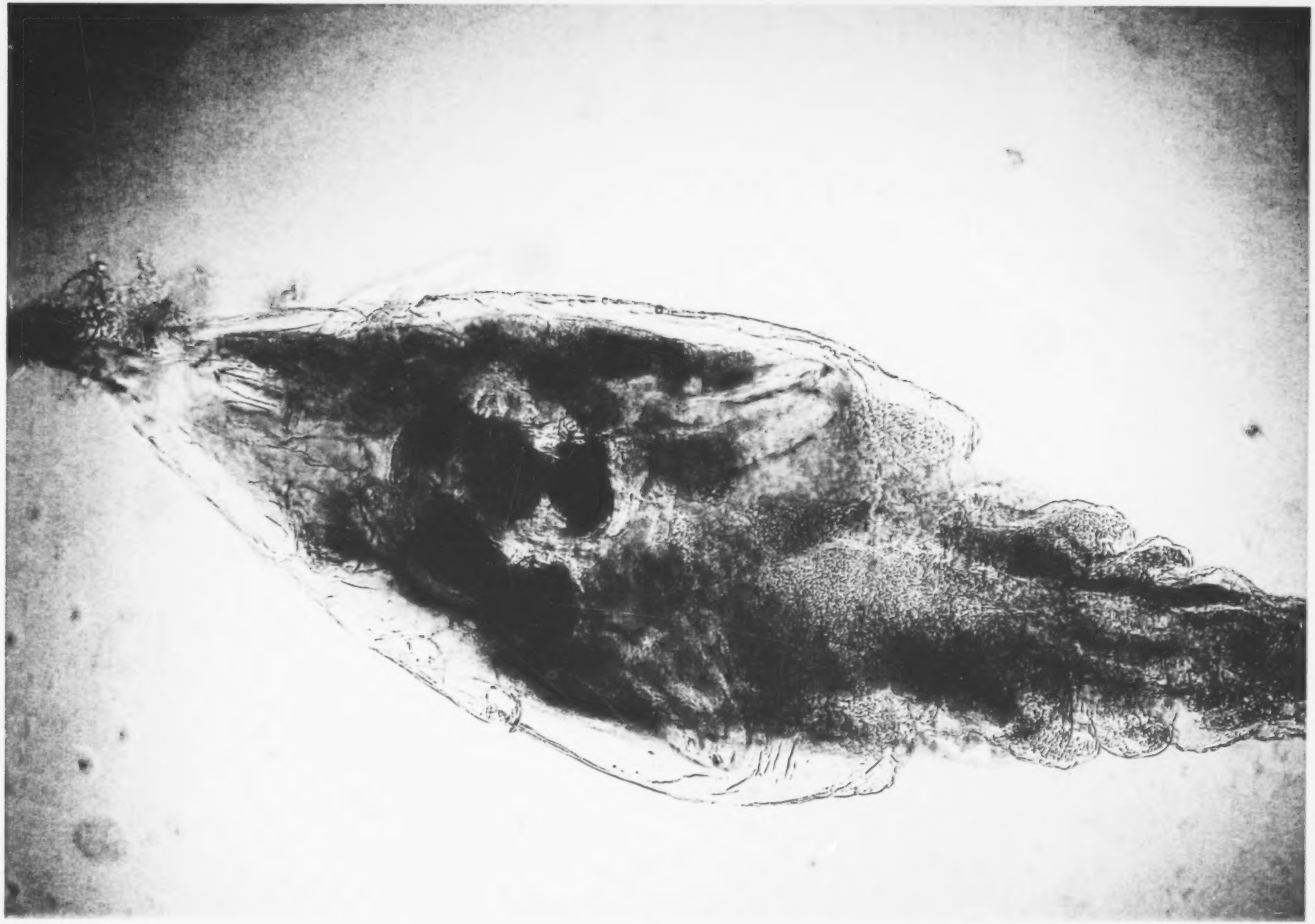
A2
MC
Mxp
Max 2

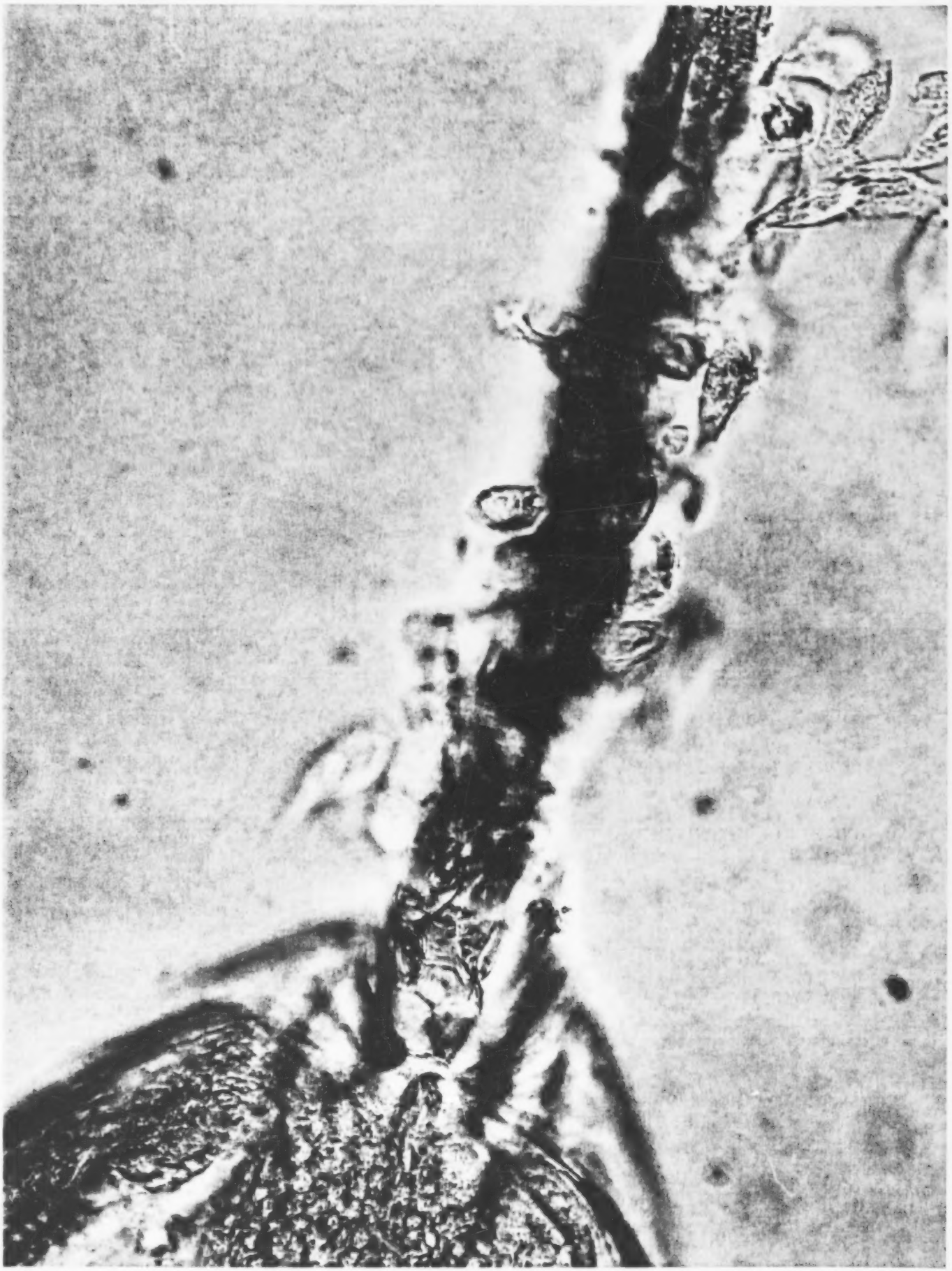


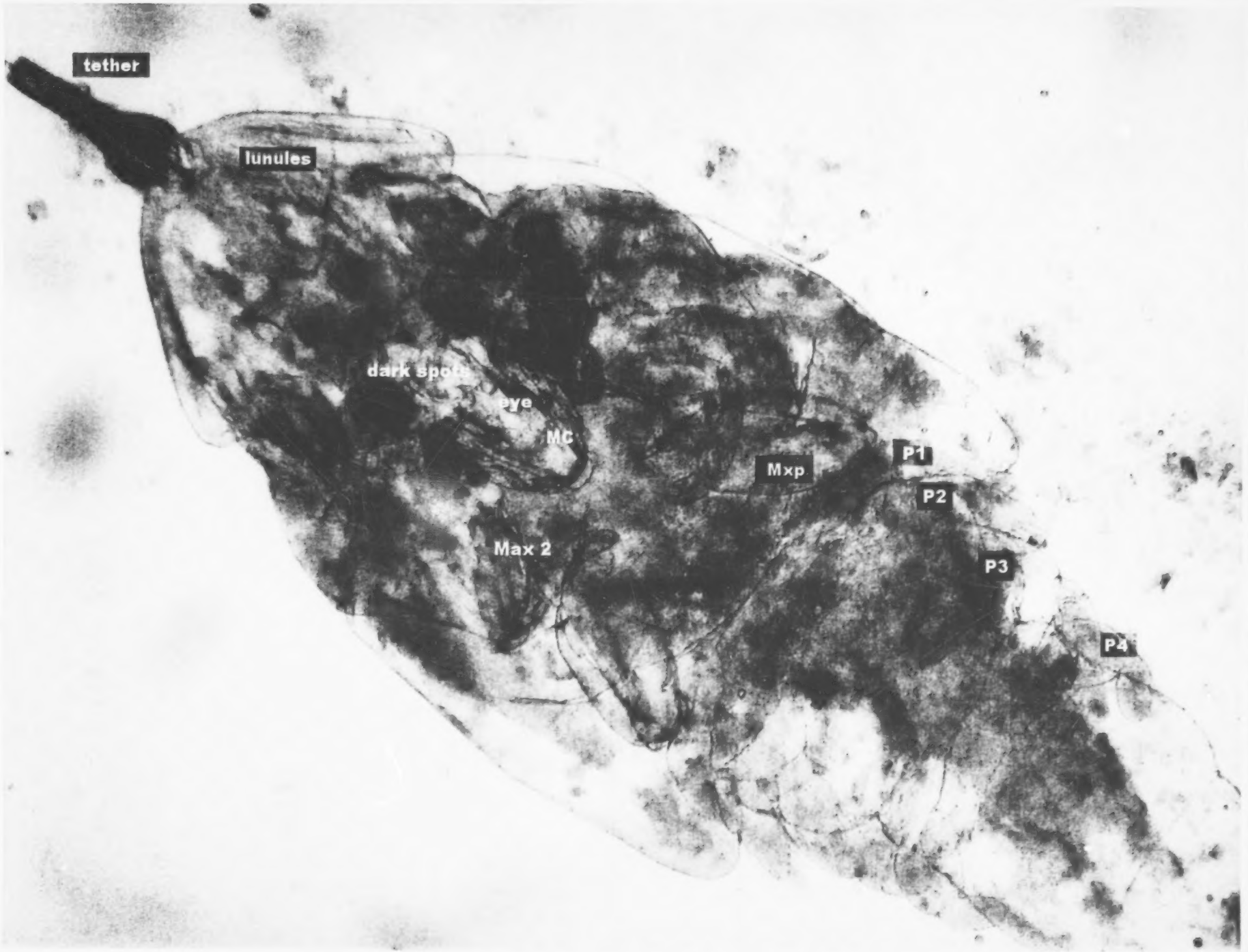
c

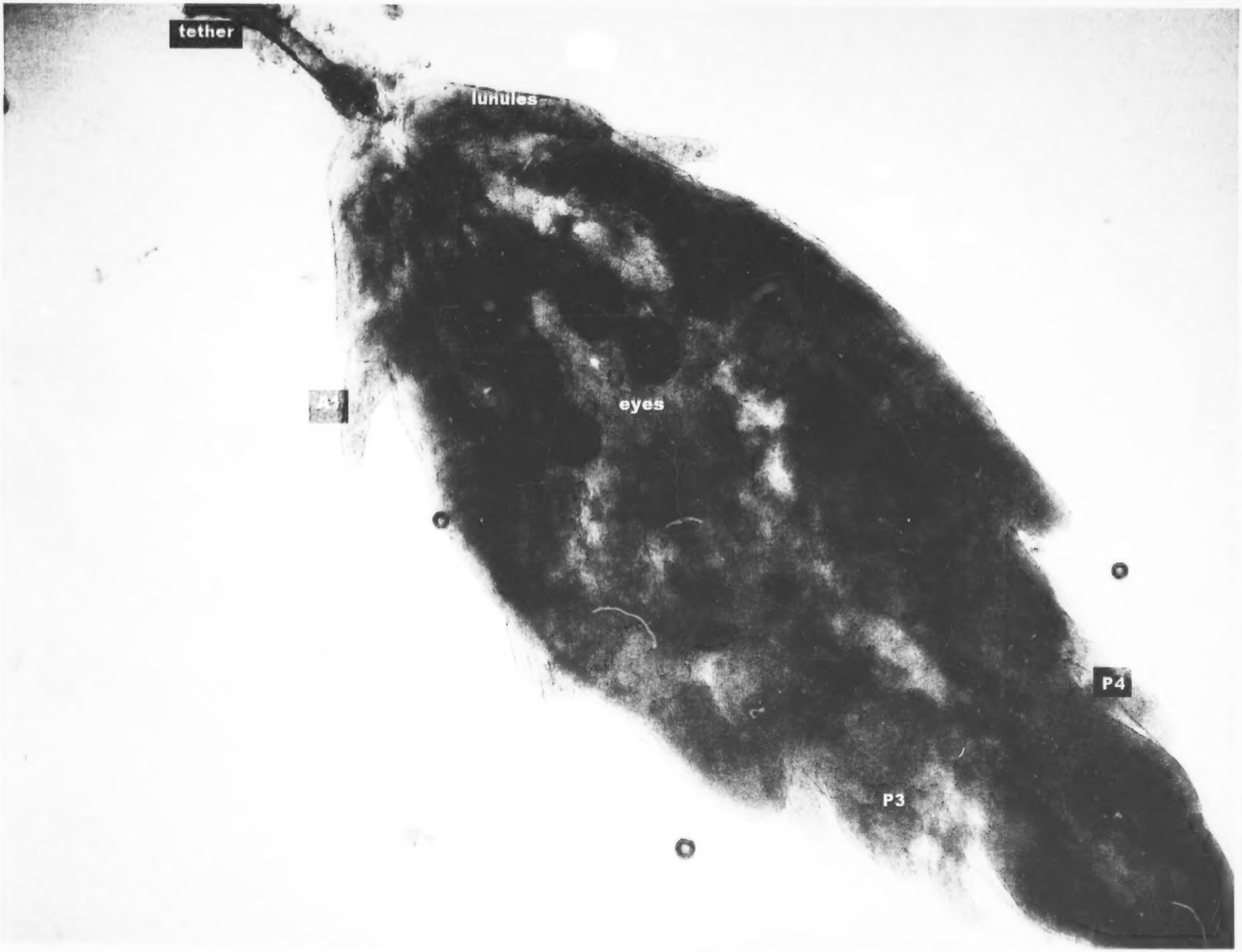


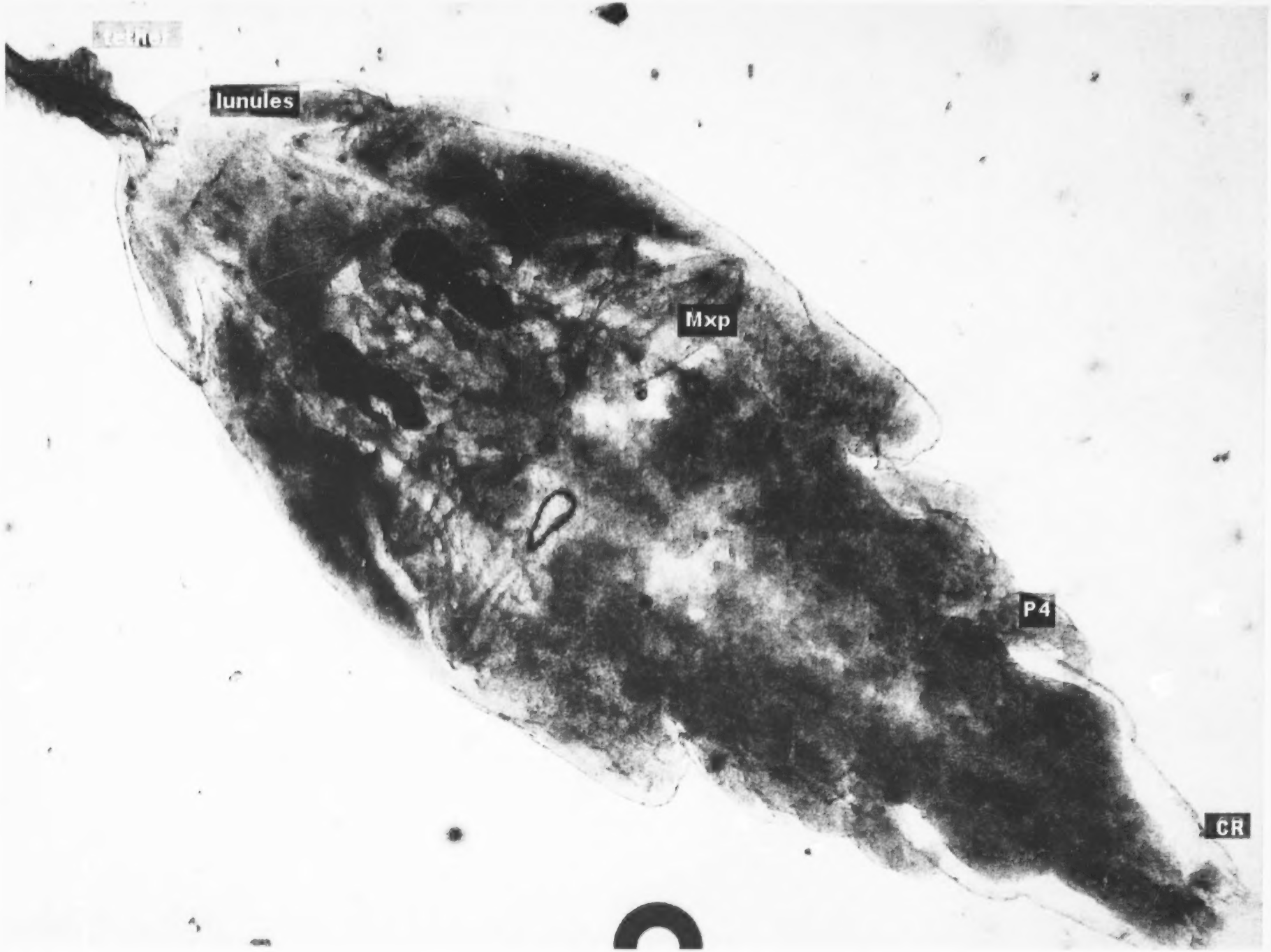

P1 B
P1 ex
P1 en
P2 ex
P2 B
P2 en

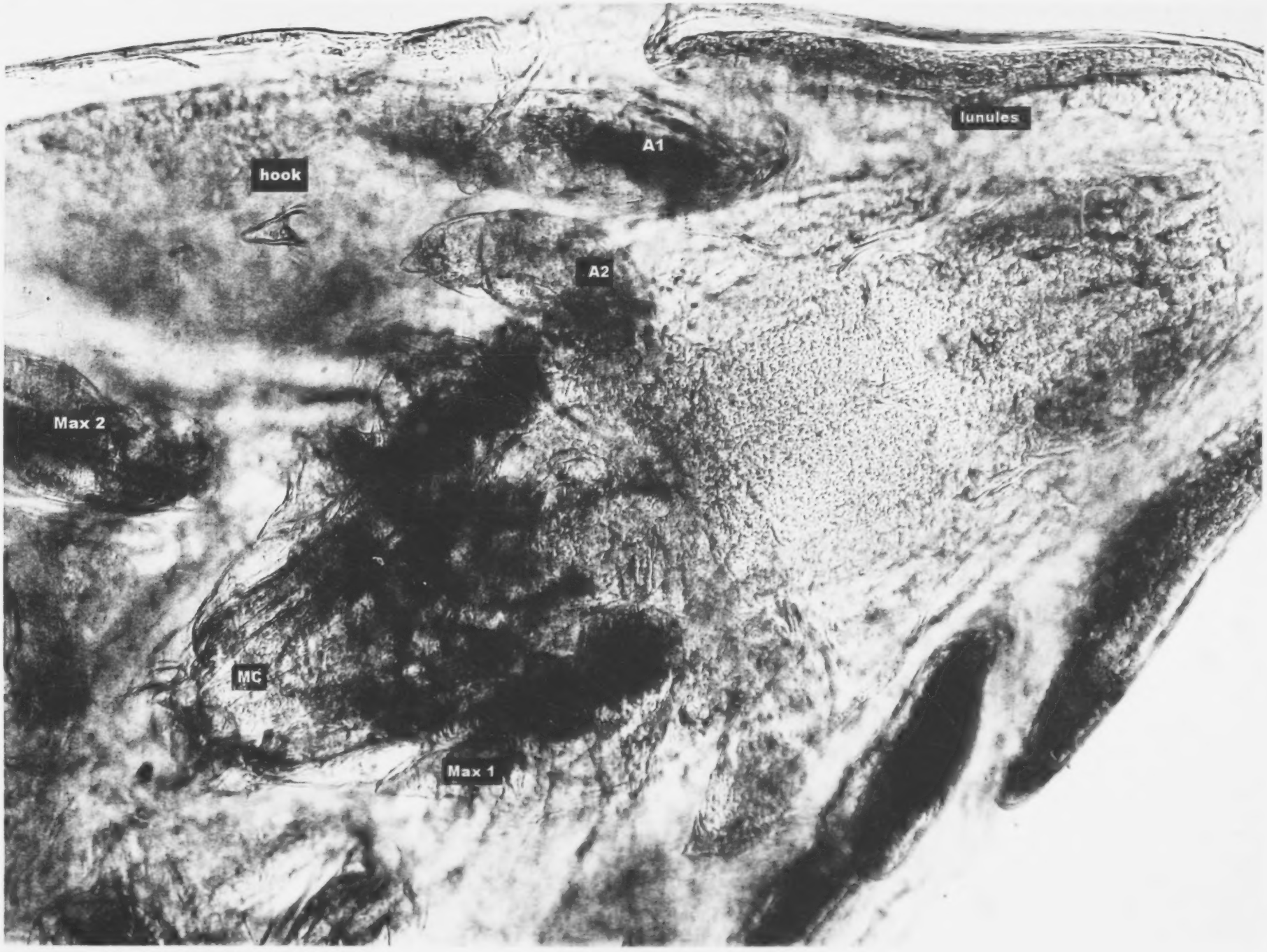


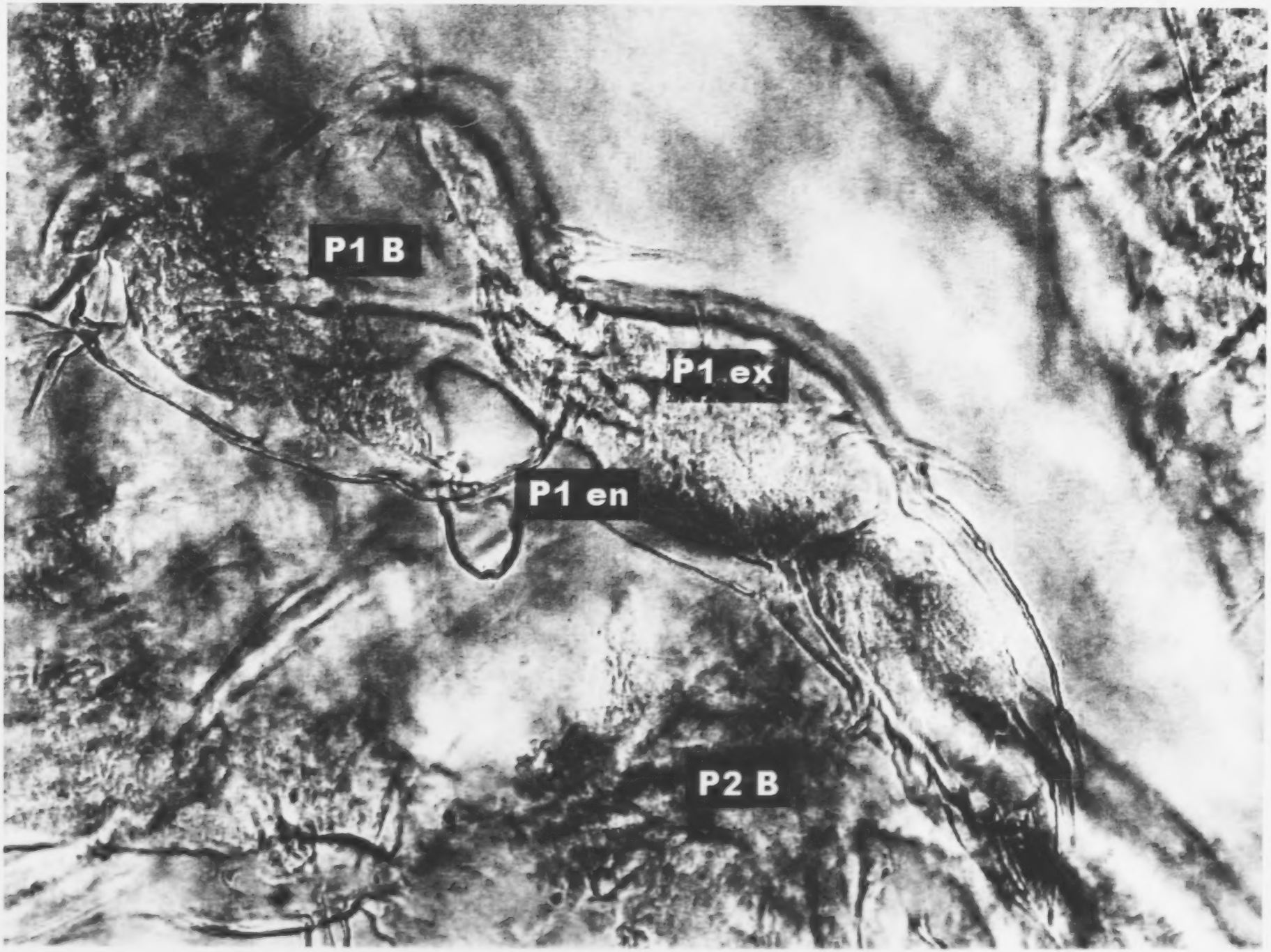


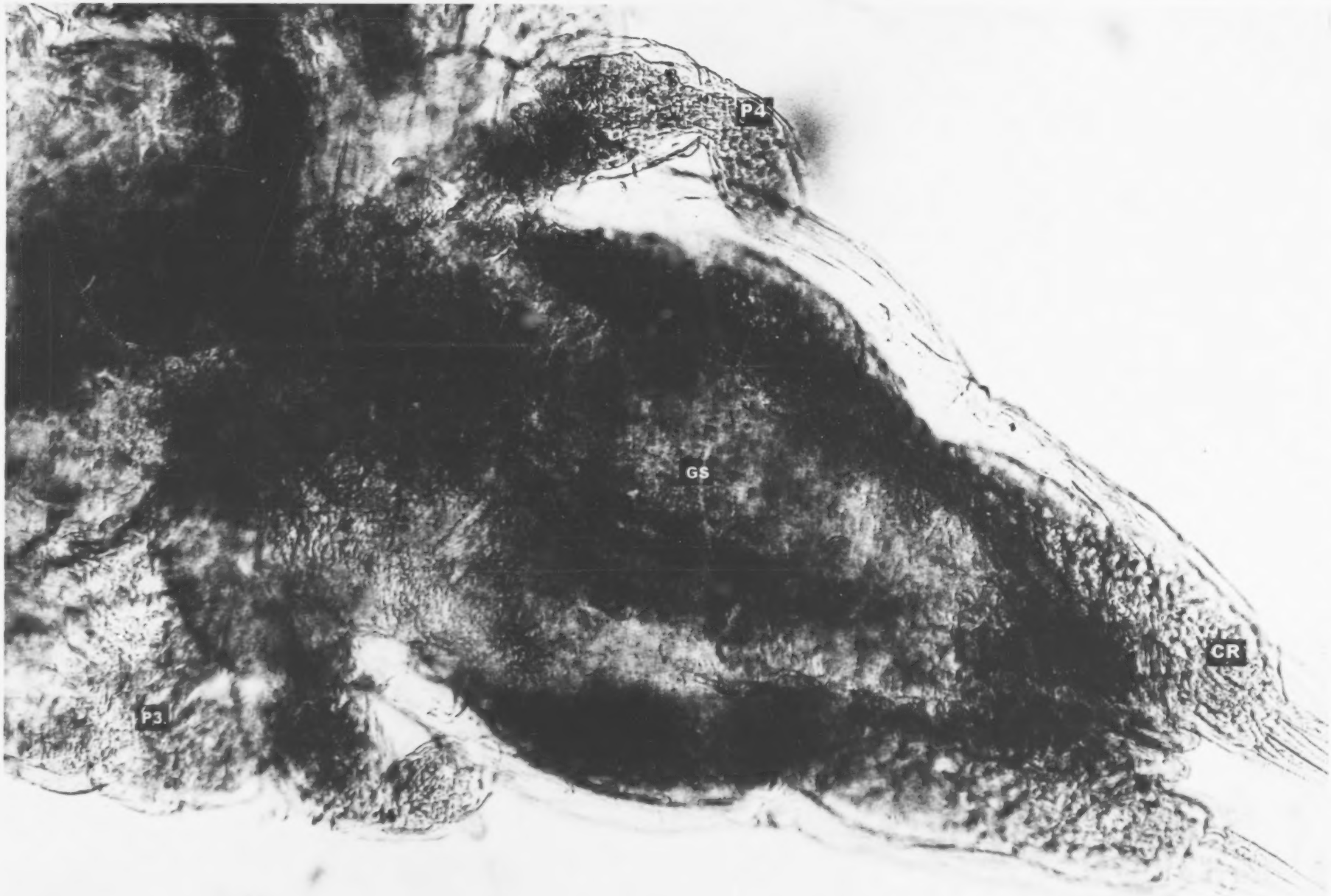

tether
lunules
dark spots
eye
MC
Mxp
P1
P2
Max 2
P3
P4

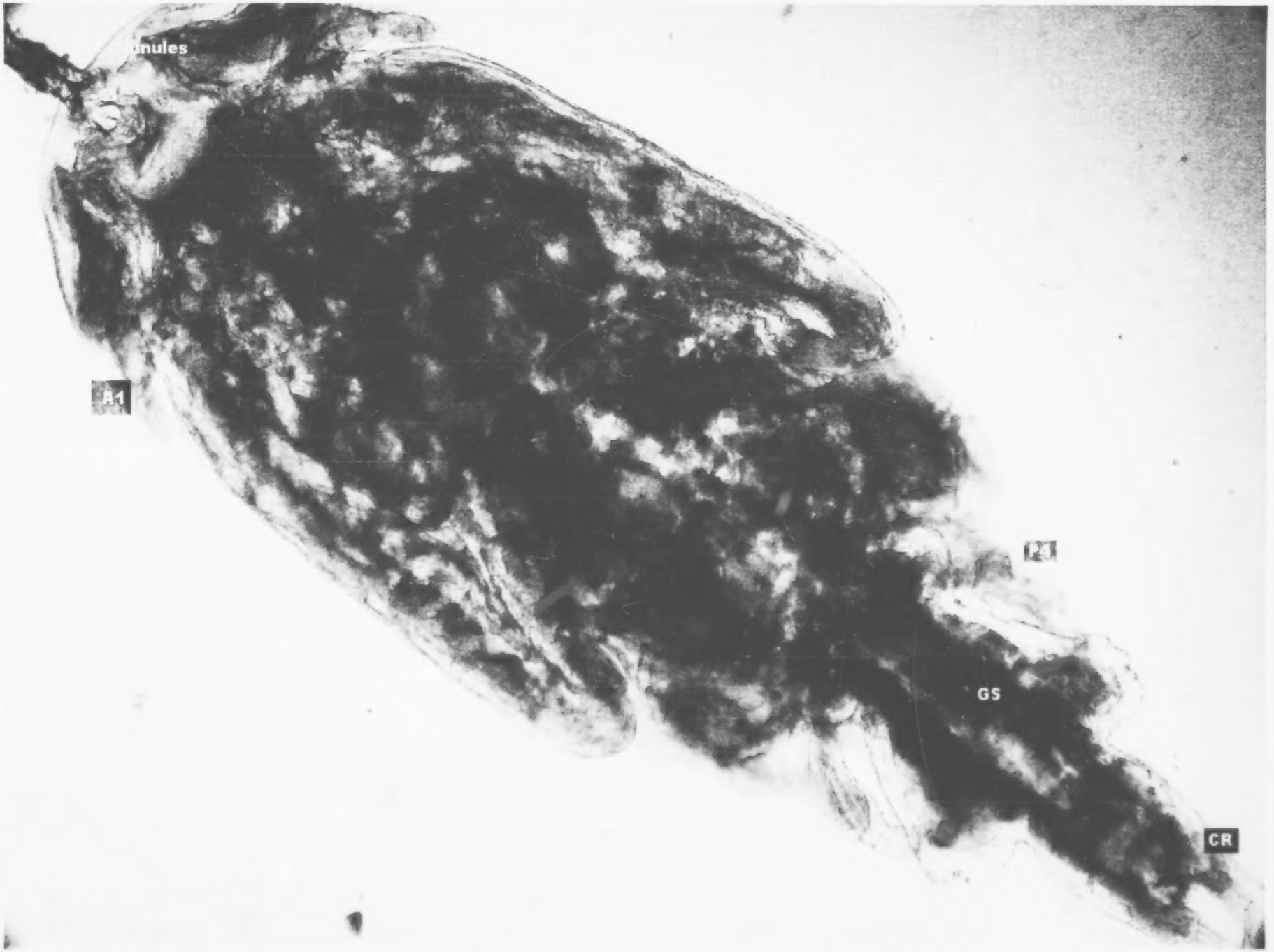

tether
tubules
eyes
P4
P3

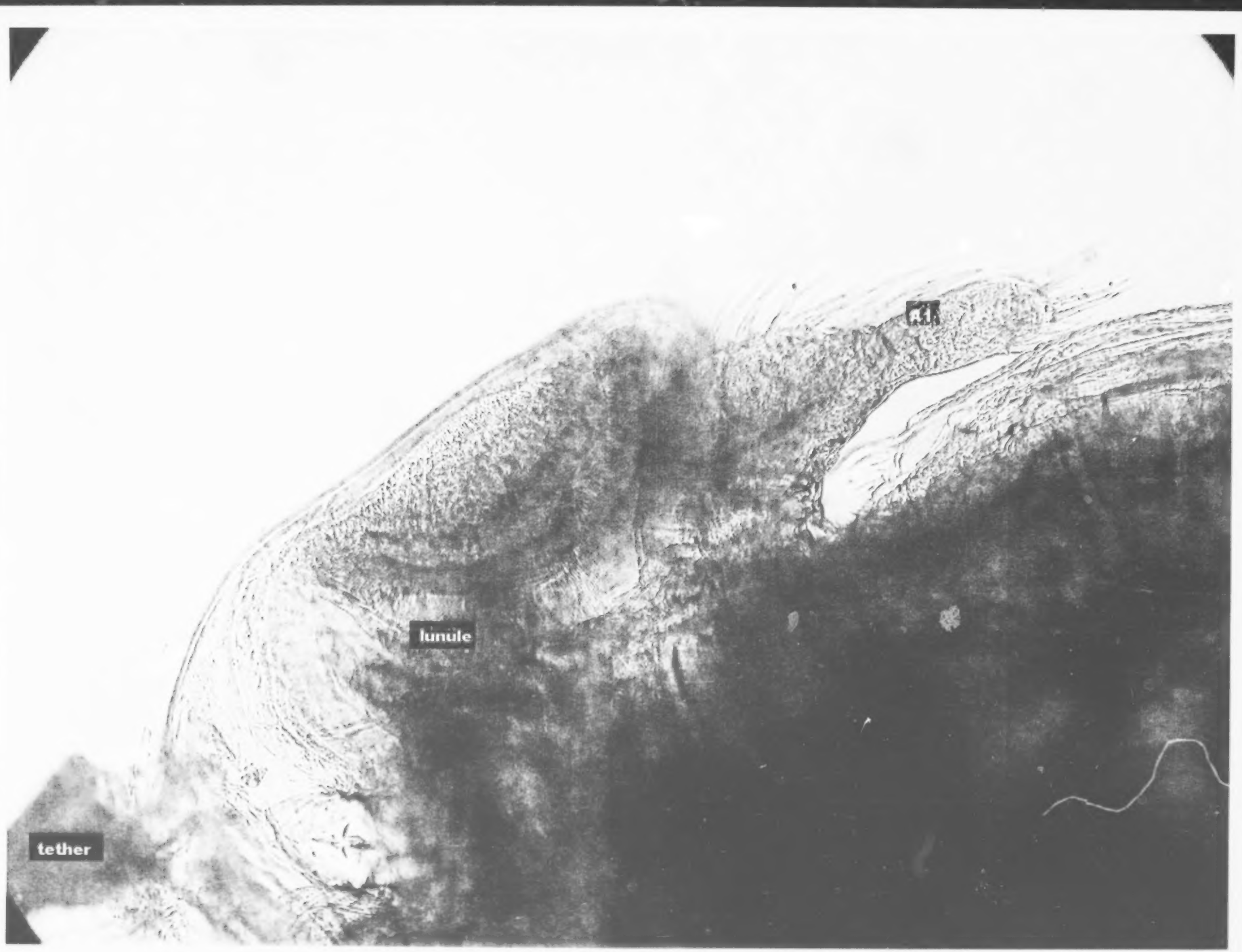

lunules
Mxp
P4
CR


lunules
A1
hook
A2
Max 2
MC
Max 1

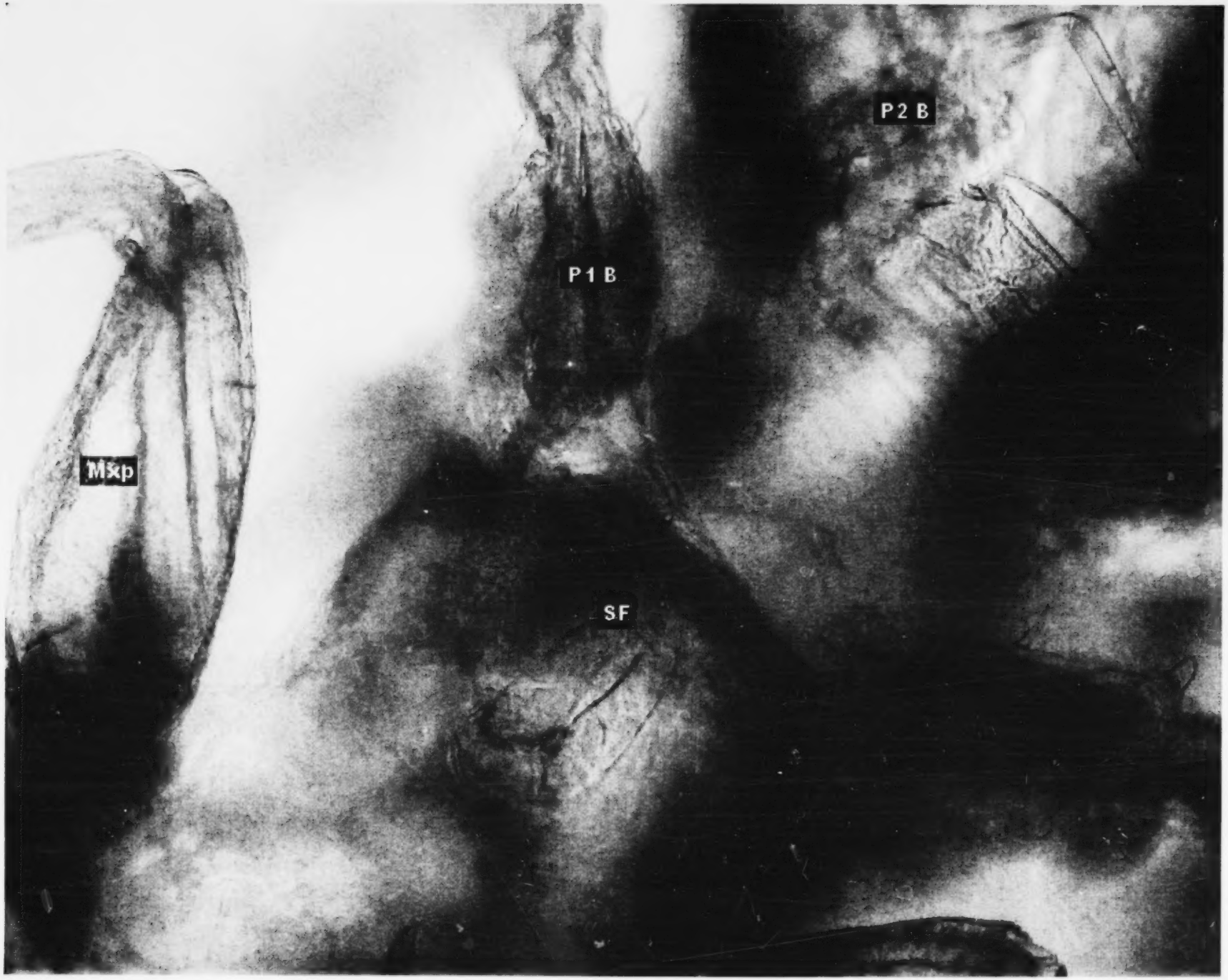

P1 B
P1 ex
P1 en
P2 B


P4
GS
CR
P3

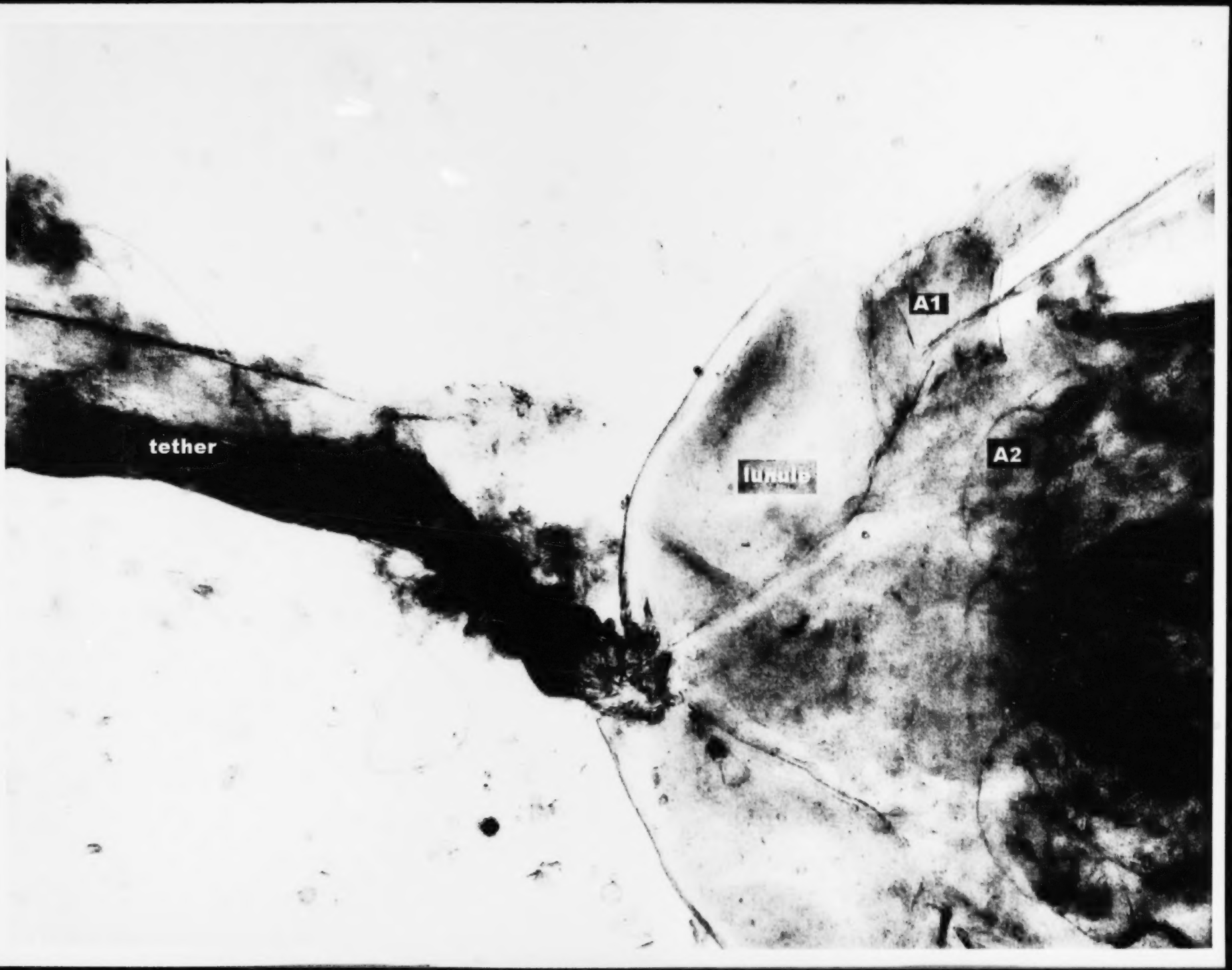

nules
A1
P1
GS
CR

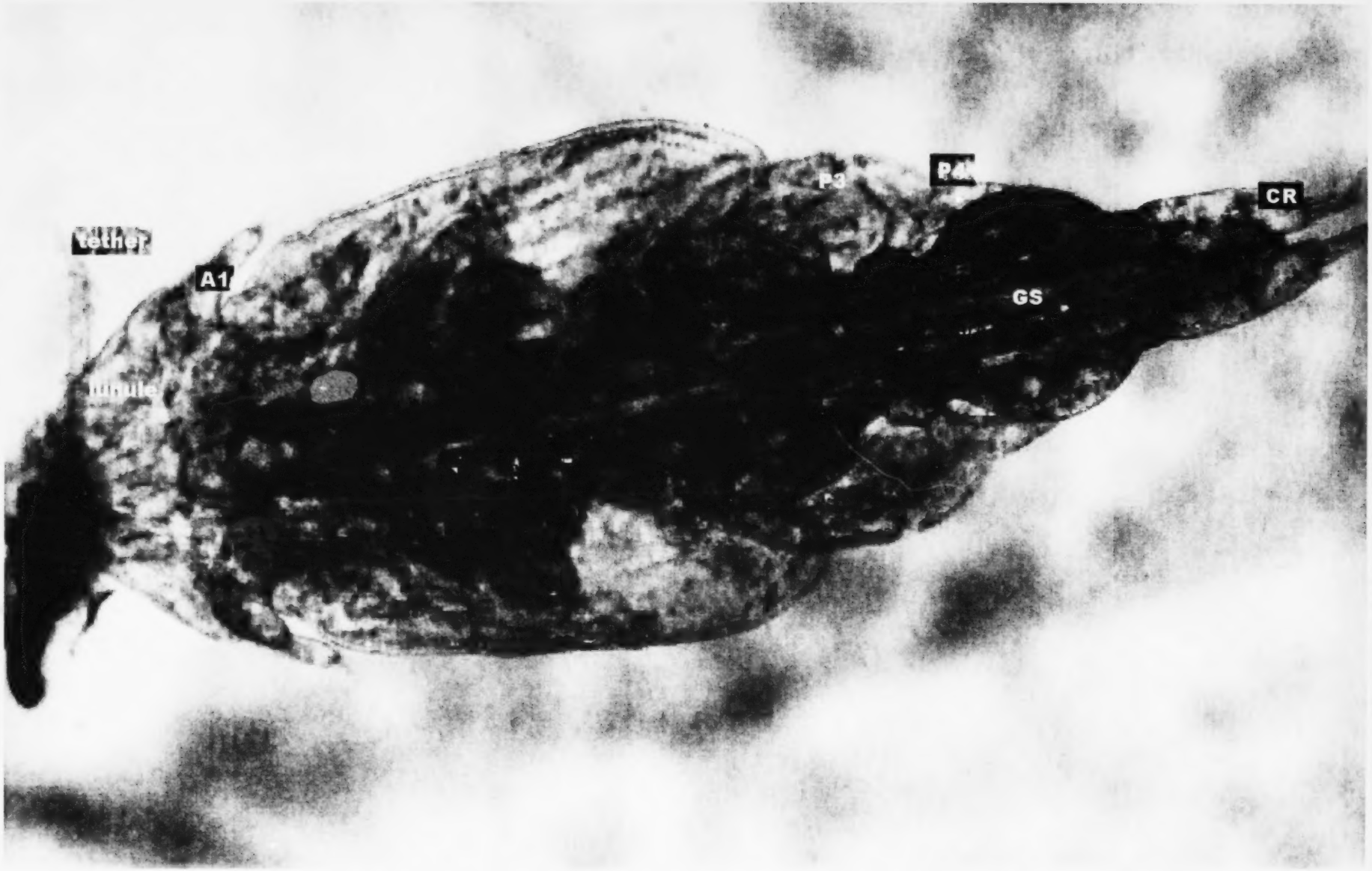

lunule
tether

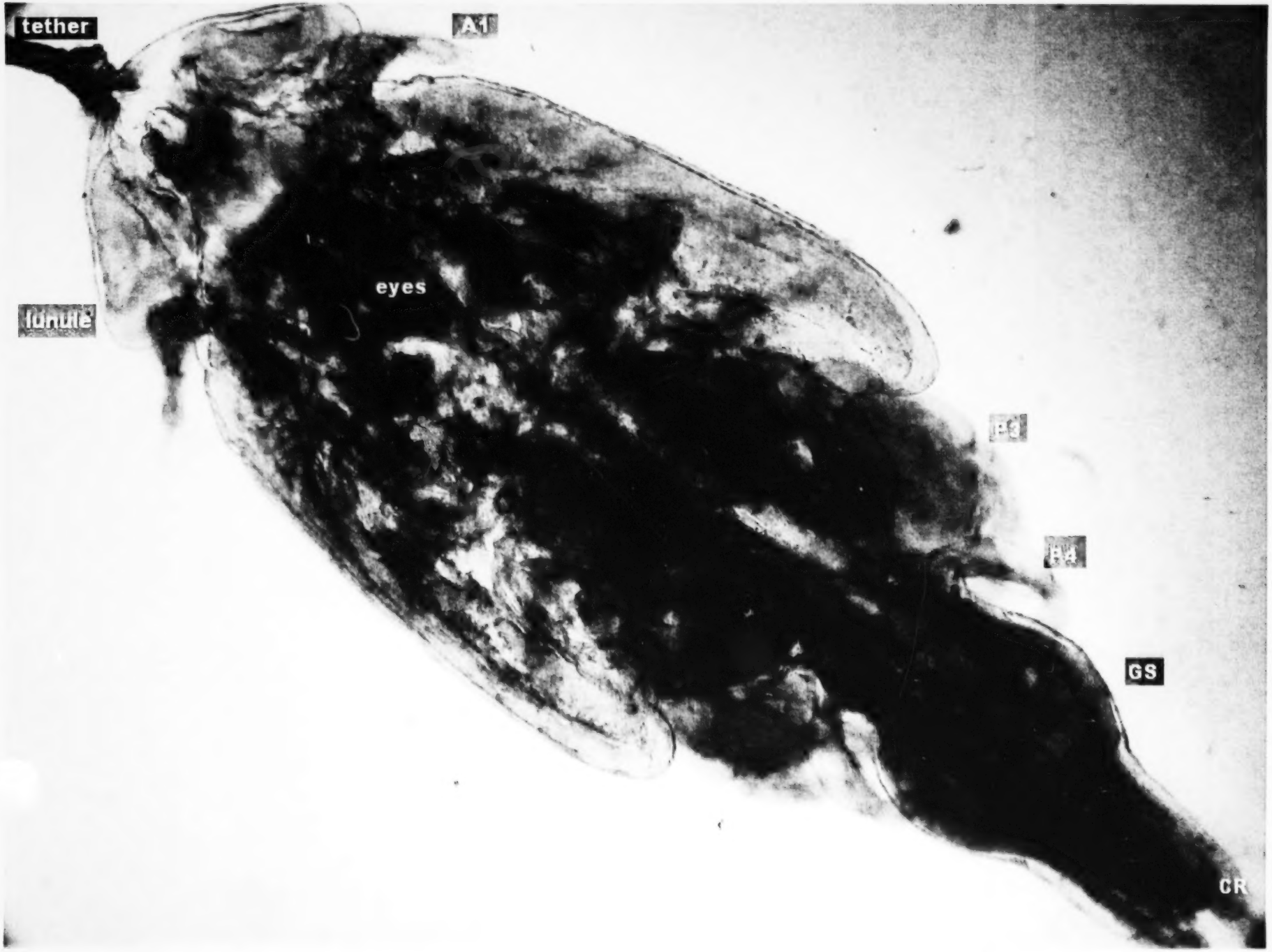
SF
Mxp
Max 2
MC
Max 1

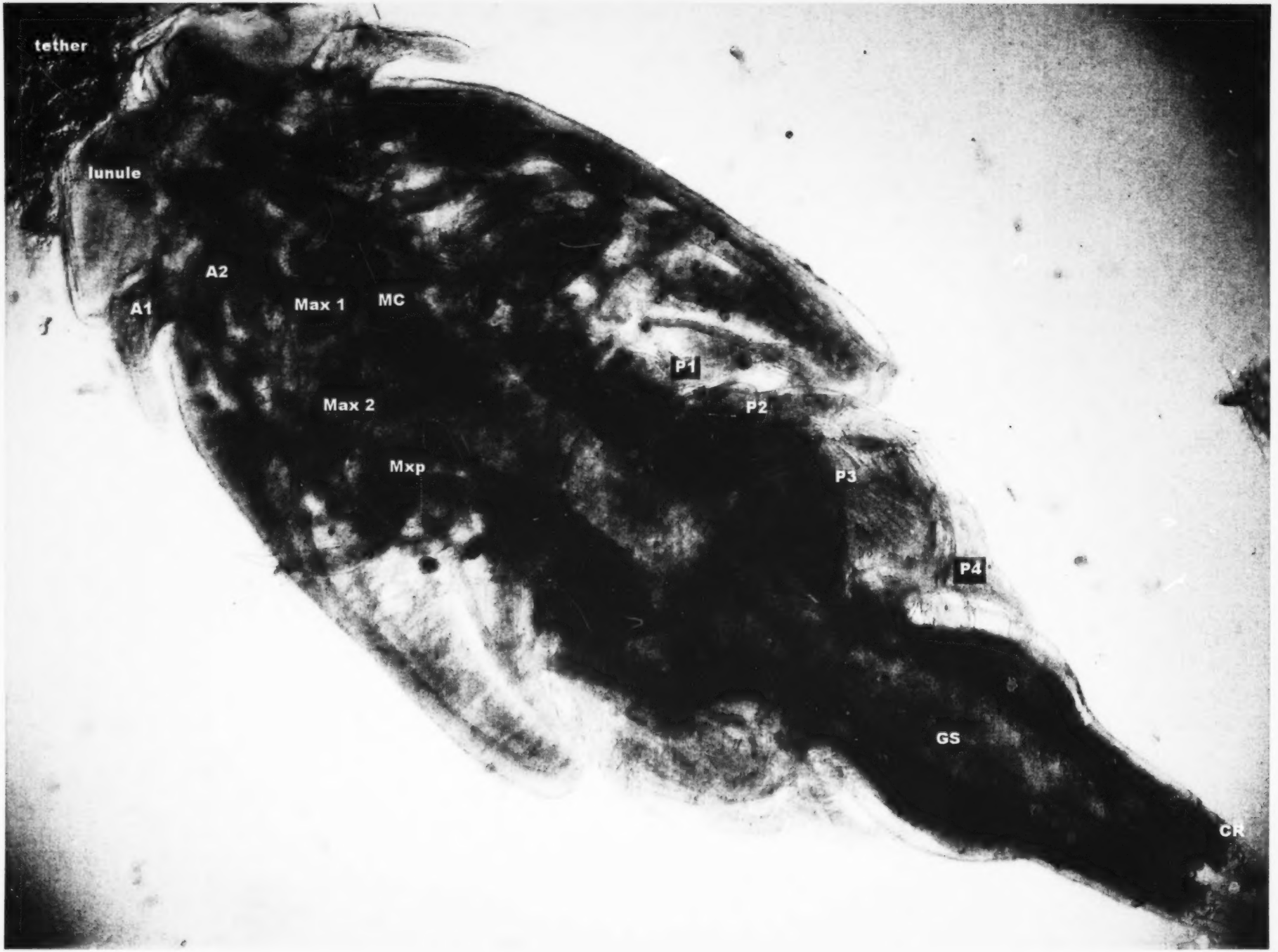

P2 B
P1 B
Mxp
SF

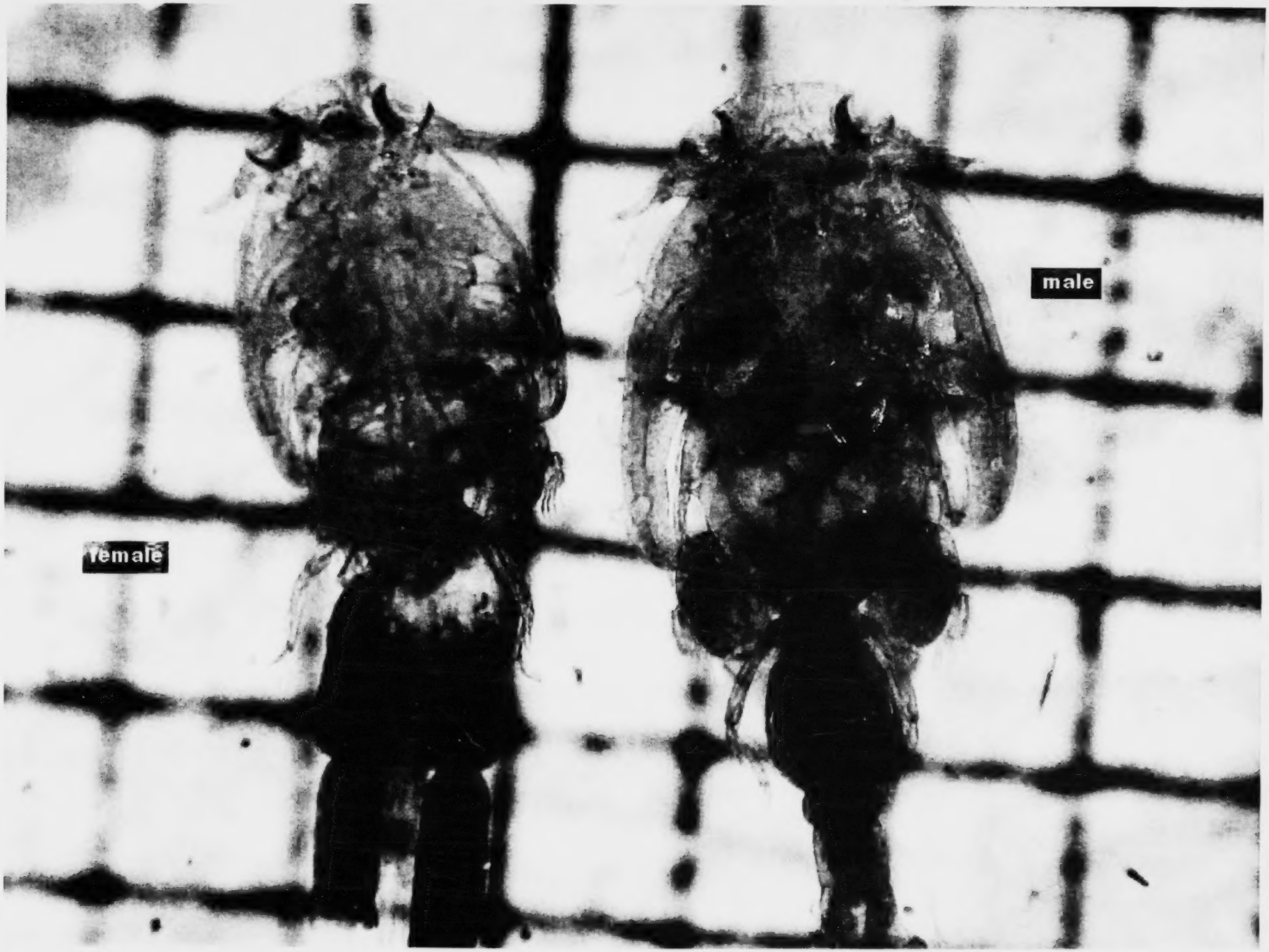
tether
lunule
A1
GS
P4
CR


tether
A1
A2


tether
A1
tubule
P3
P4
GS
CR


tether
A1
eyes
lunule
P3
P4
GS
CR


tether
lunule
A2
A1
Max 1
MC
P1
Max 2
P2
Mxp
P3
P4
GS
CR


male
female

sub adult 2 male salmonis
adult male salmonis
female clemensi
ch4 female clemensi

salmonis

a copepodid max2 and mxp.jpg

a copepodid mxp tine close up.jpg

a copepodid ventral.jpg

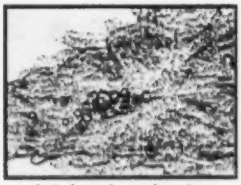
attached copepodid lateral.jpg

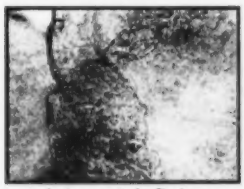
attached copepodid moulting.jpg

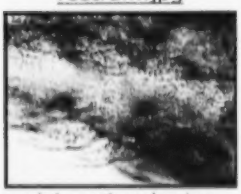
attached copepodid rostrum.jpg

attached copepodid ventral.jpg

ch1 a p1 nubs.jpg


ch1 b p1 nubs.jpg


ch1 c p1 left.jpg


ch1 c p1 nubs.jpg

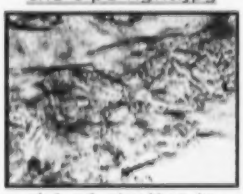
ch1 c p1 right.jpg

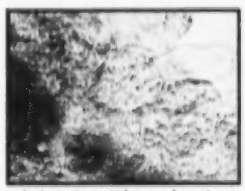
ch1 d lateral.jpg

ch1 dorsal.jpg

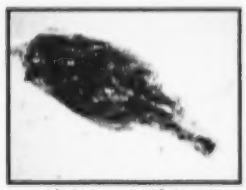
ch1 p1 nub.jpg

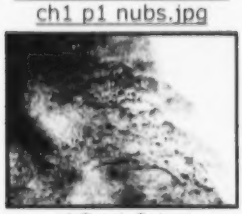
ch1 p1 nubs.jpg

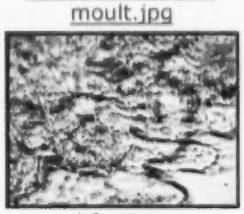

ch1 p1 starting to moult.jpg

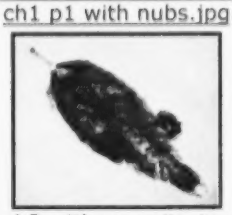

ch1 p1 with nubs.jpg

ch1 urosome.jpg

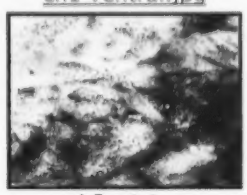

ch1 ventral.jpg


ch2 p1 2.jpg


ch2 p1.jpg

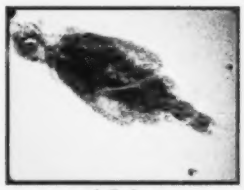

ch2 with parasite.jpg

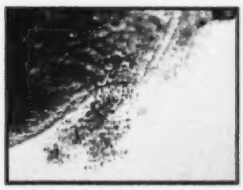
ch2.jpg

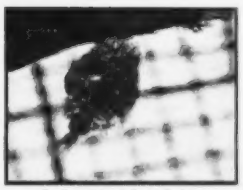

ch3 p1.jpg

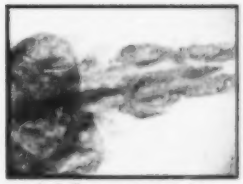
salmonis

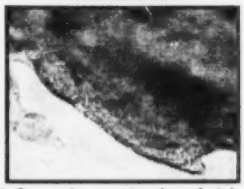
ch3 sf.jpg

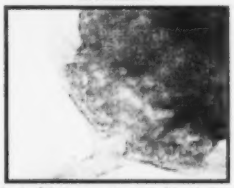

ch3.jpg

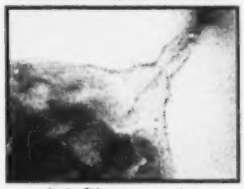

ch4 a1 with epi.jpg

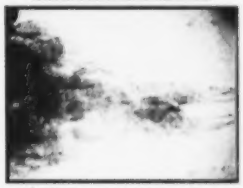

ch4 attached.jpg


ch4 f urosome.jpg


ch4 female cuticular fold.jpg

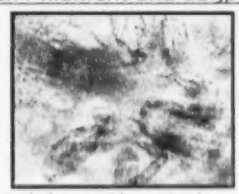

ch4 filament and a1.jpg


ch4 filament.jpg


ch4 m urosome.jpg

ch4 m ventral.jpg

ch4 m with parasite.jpg

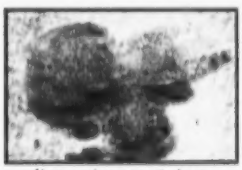

ch4 mouthparts.jpg

ch4 mp.jpg

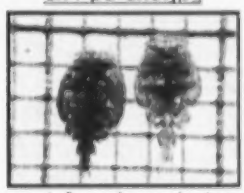
ch4 p1 exo.jpg

ch4 sf.jpg

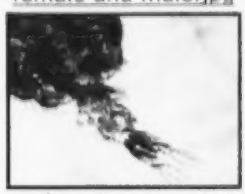
female and male.jpg


live pigment.jpg

male in ethanol.jpg


sa 1 female male.jpg

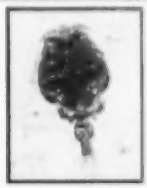
sa 1 female .jpg


sa 1 female urosome.jpg

sa 1 female.jpg

sa 1 male urosome.jpg

sa 1 male with tether.jpg


sa 1 male.jpg

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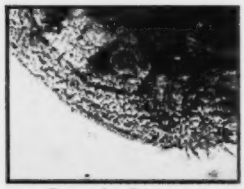
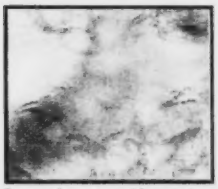
salmonis

sa 2 female.jpg

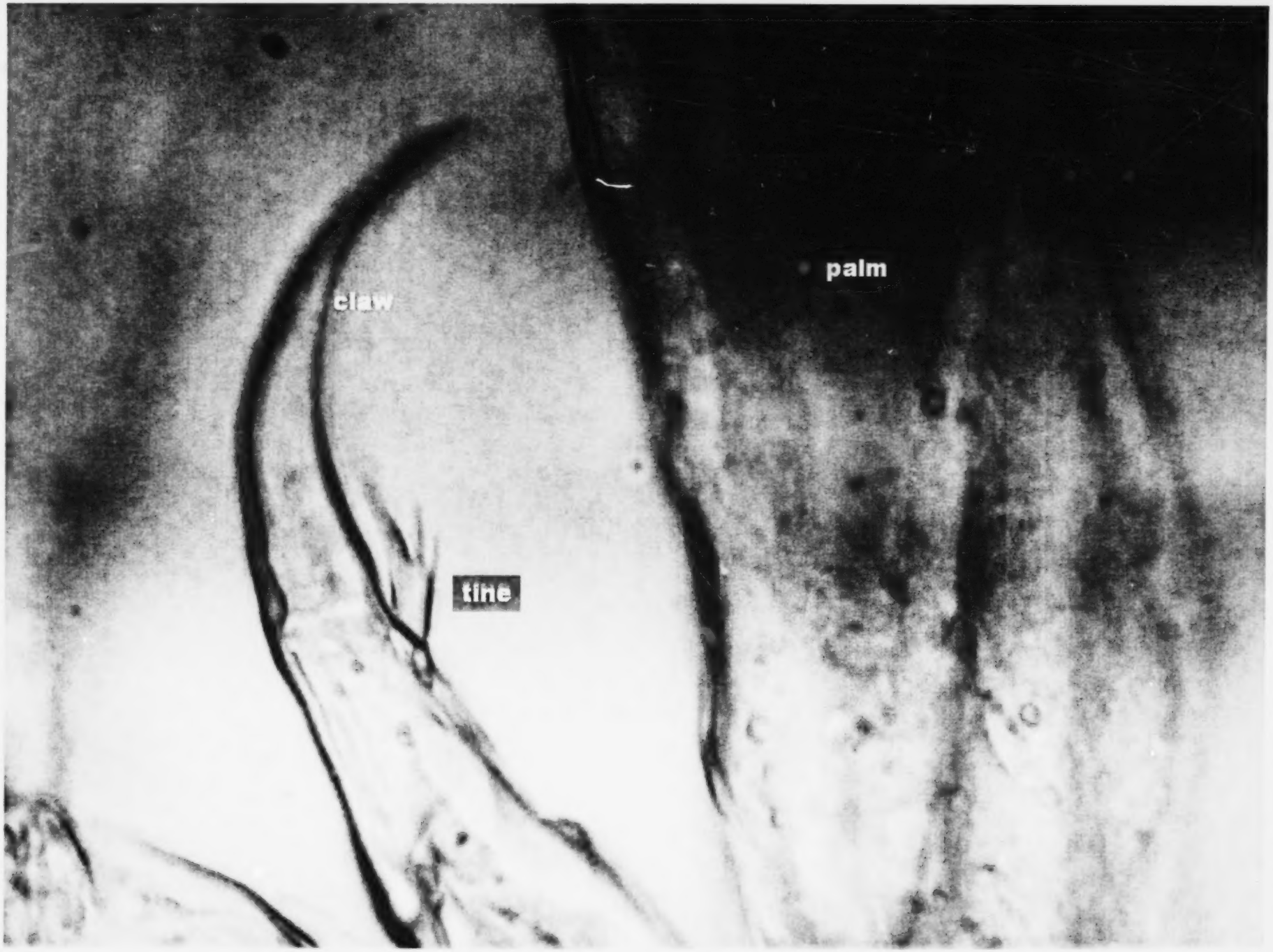

sa 2 male fringe.jpg

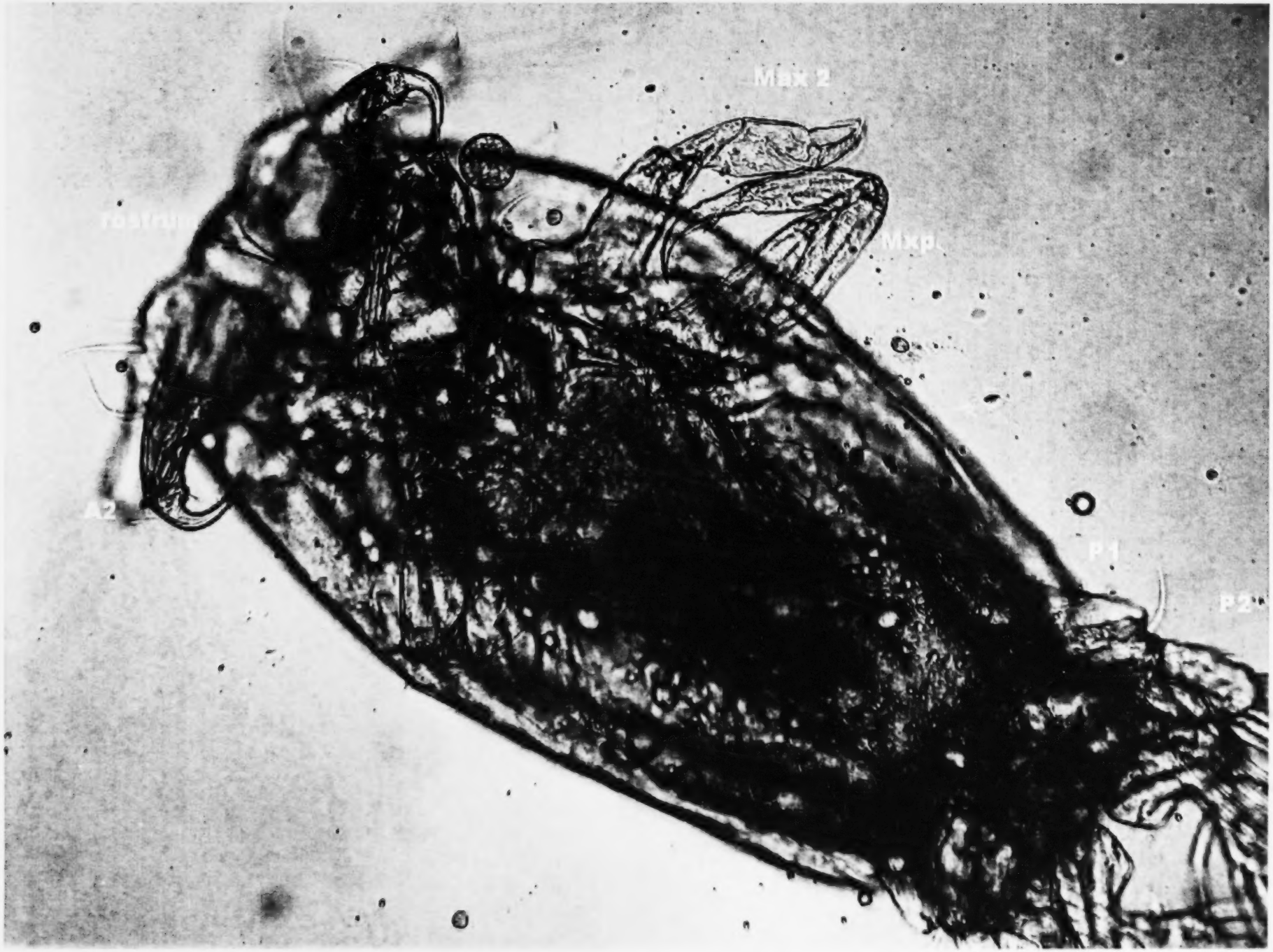

sa 2 male mouthparts.jpg

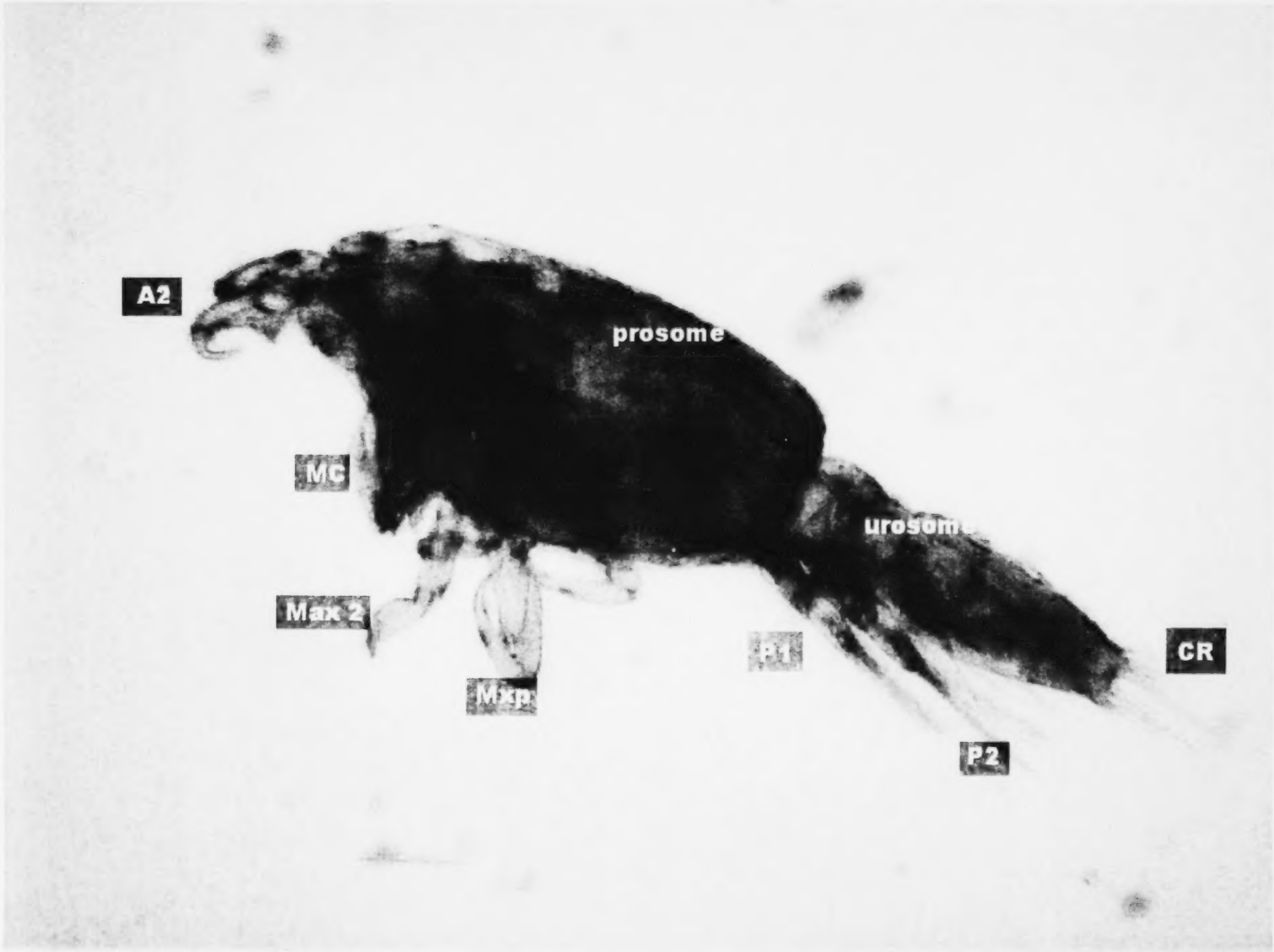
sa 2 male p5 p6.jpg

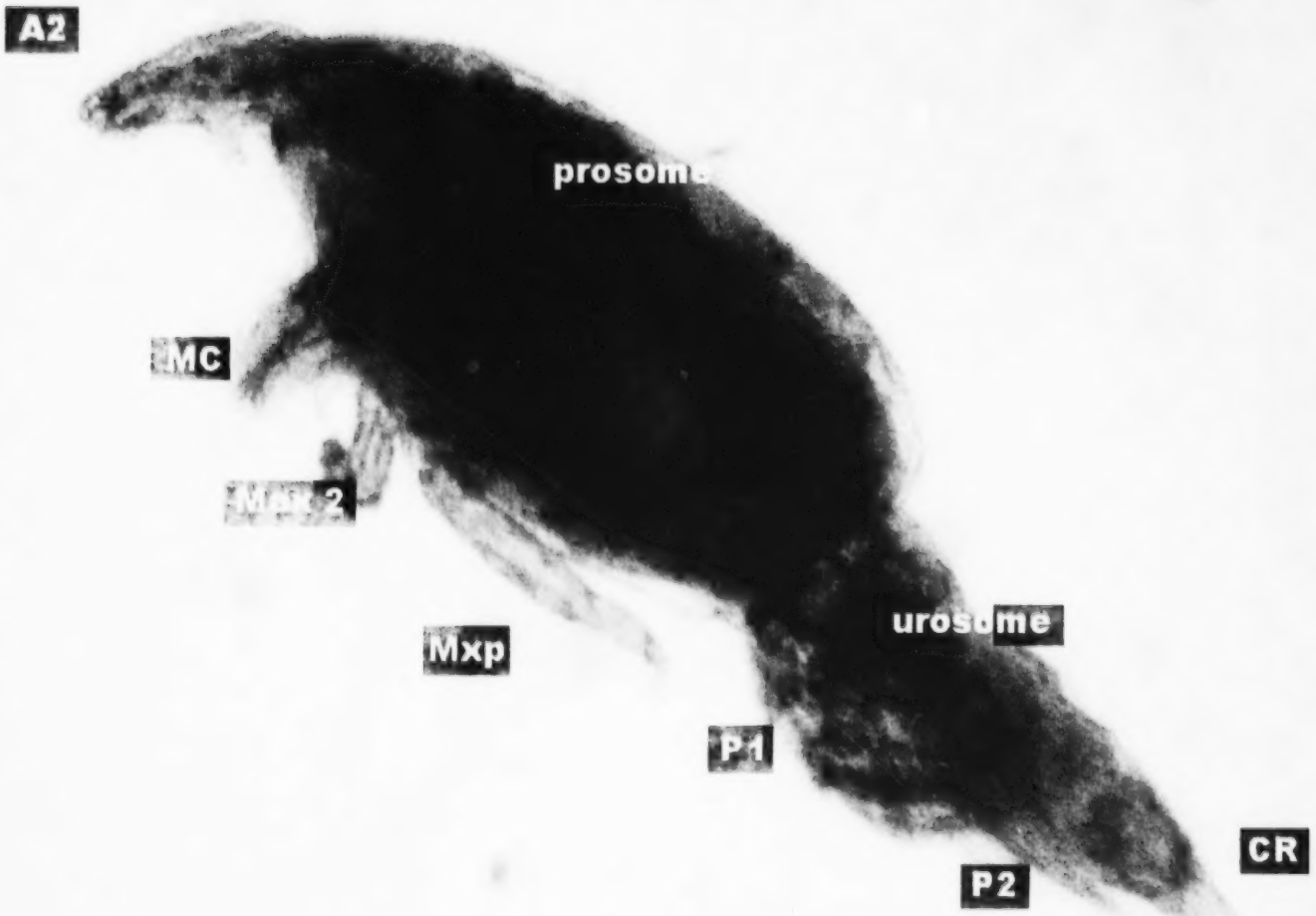
sa 2 male.jpg

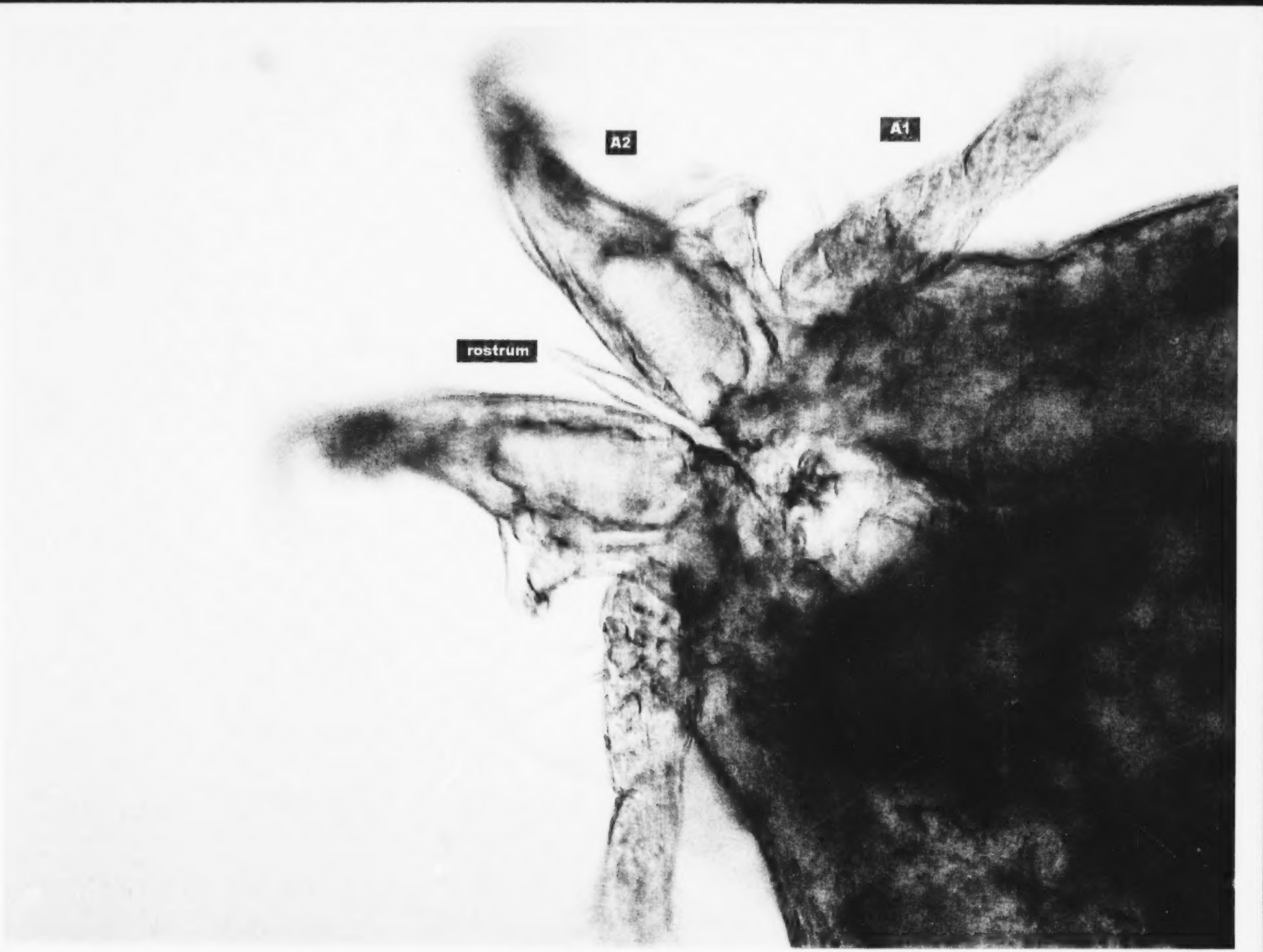
tine
Mxp
Max 2

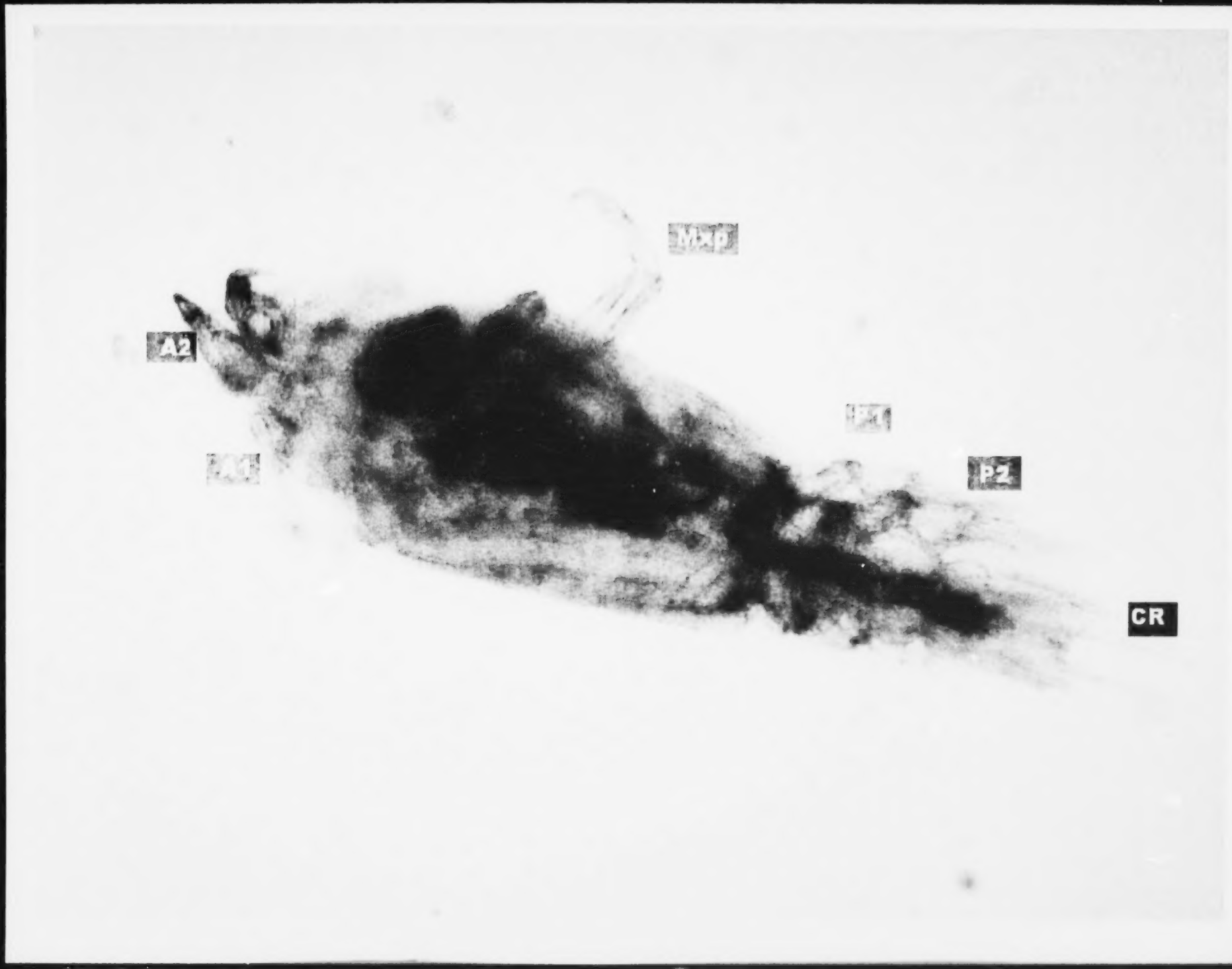

palm
claw
fine

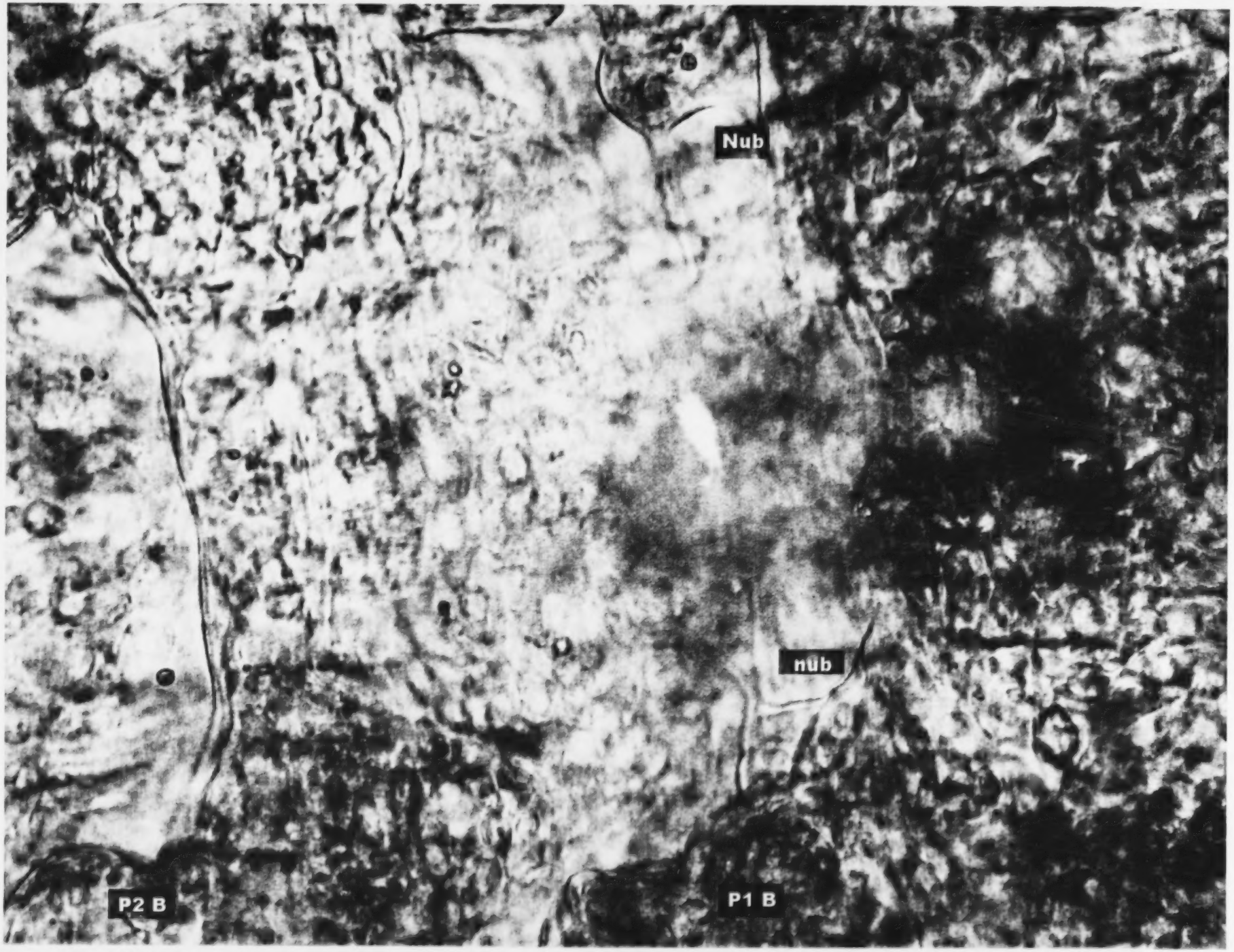

Mxp
A2
P1
P2

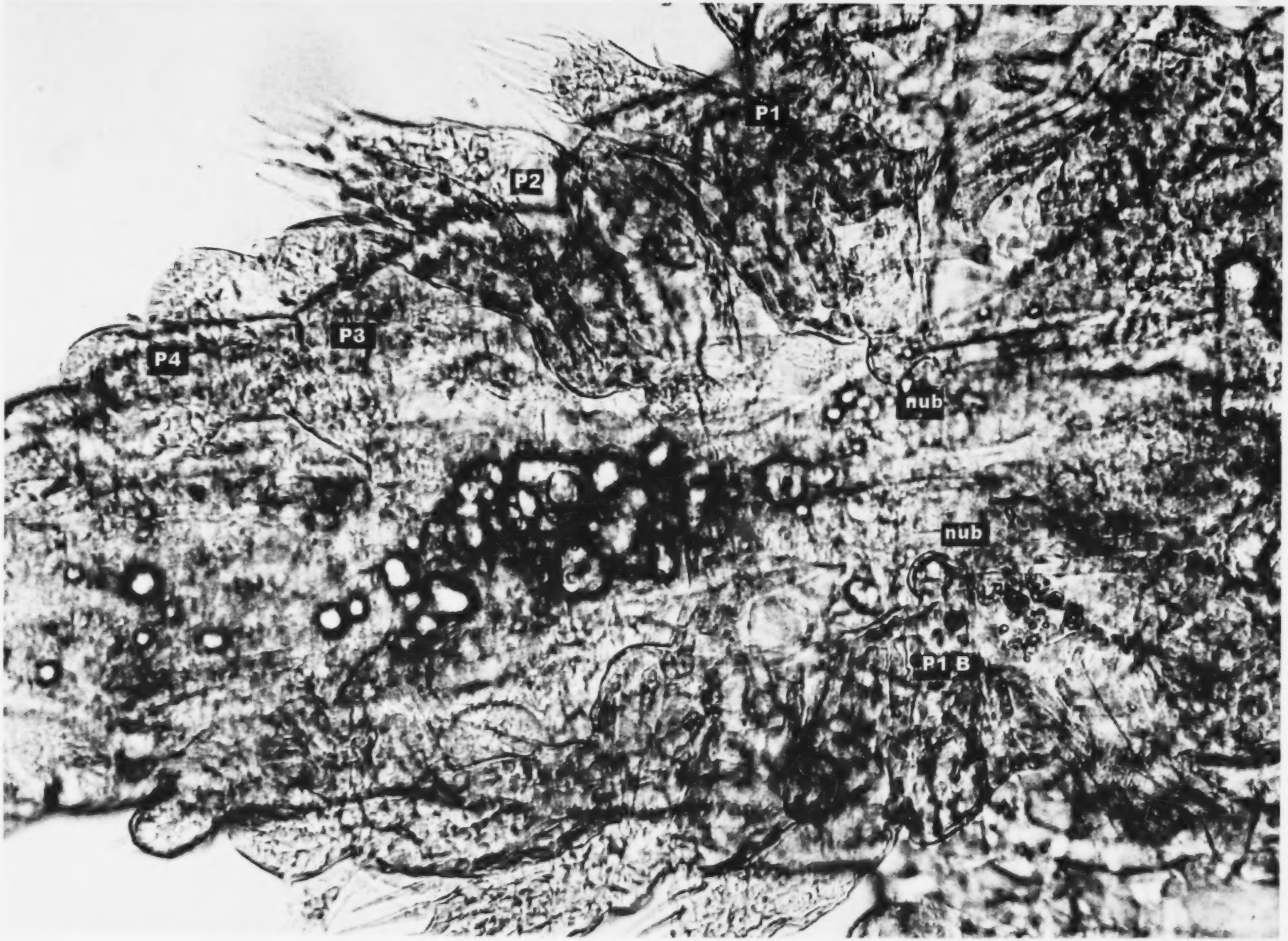

A2
prosome
MC
urosom
Max 2
P1
CR
Mxp
P2

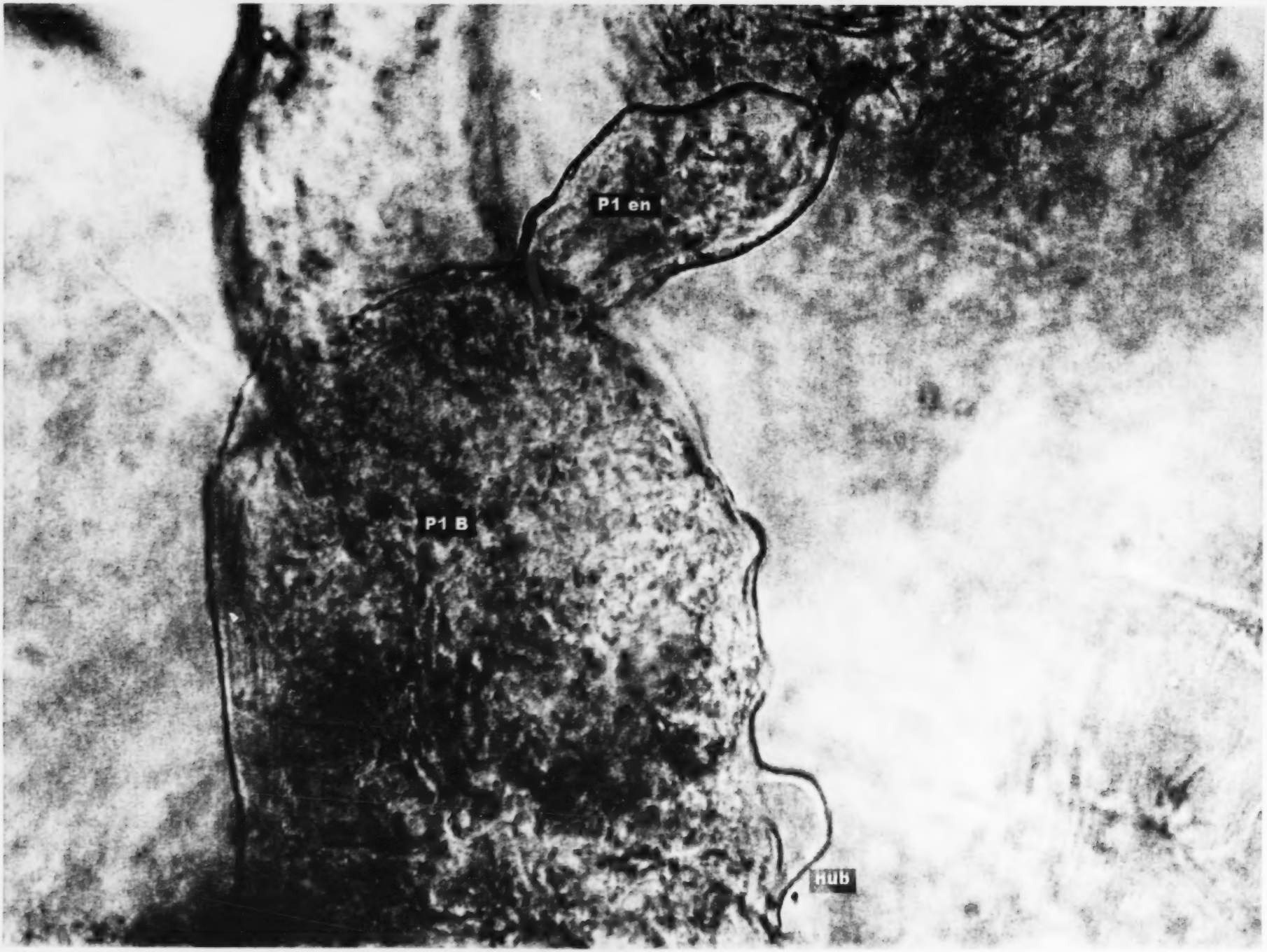

A2
prosome
MC
urosome
Mxp
P1
CR
P2

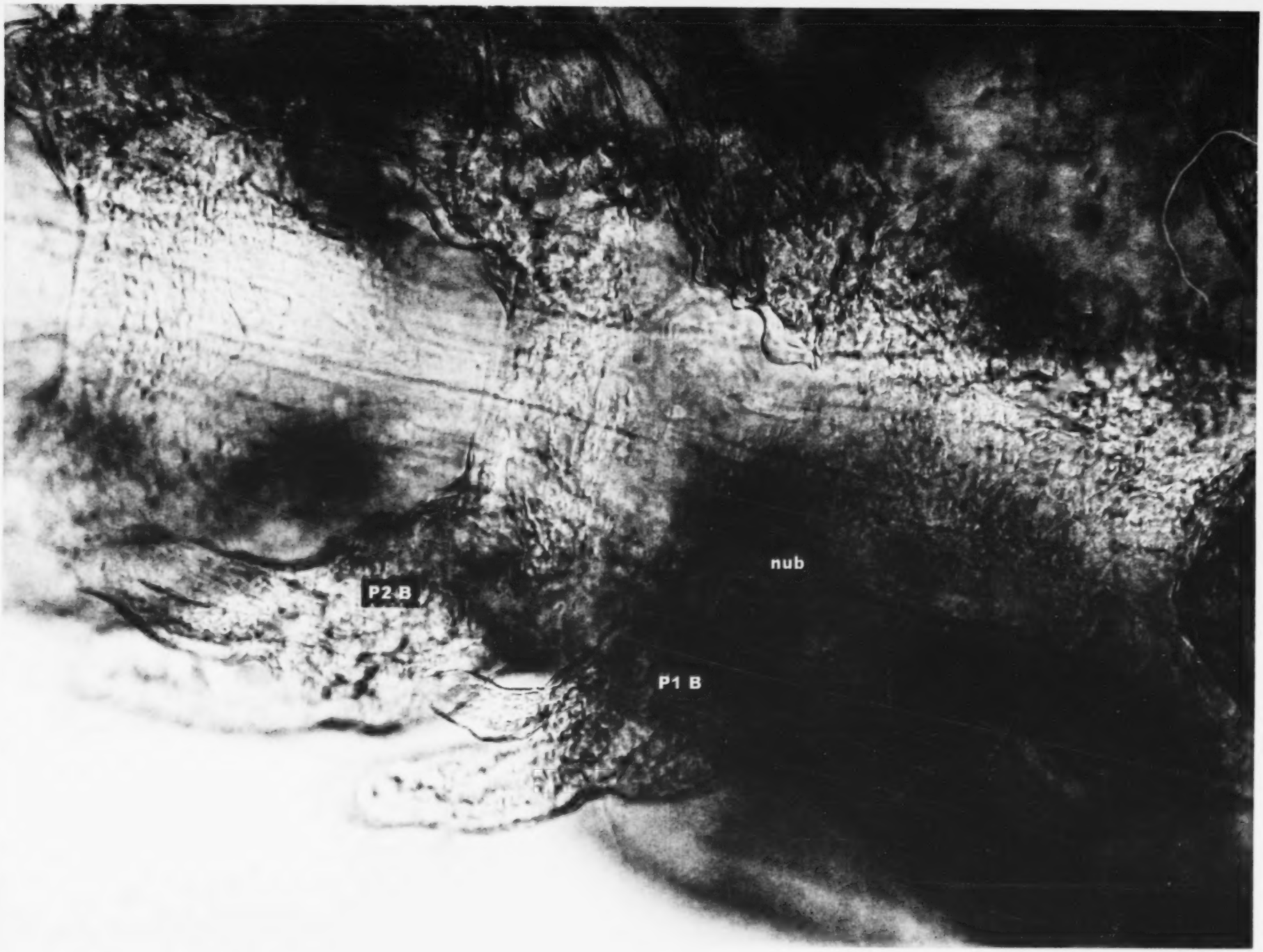

A2
A1
rostrum

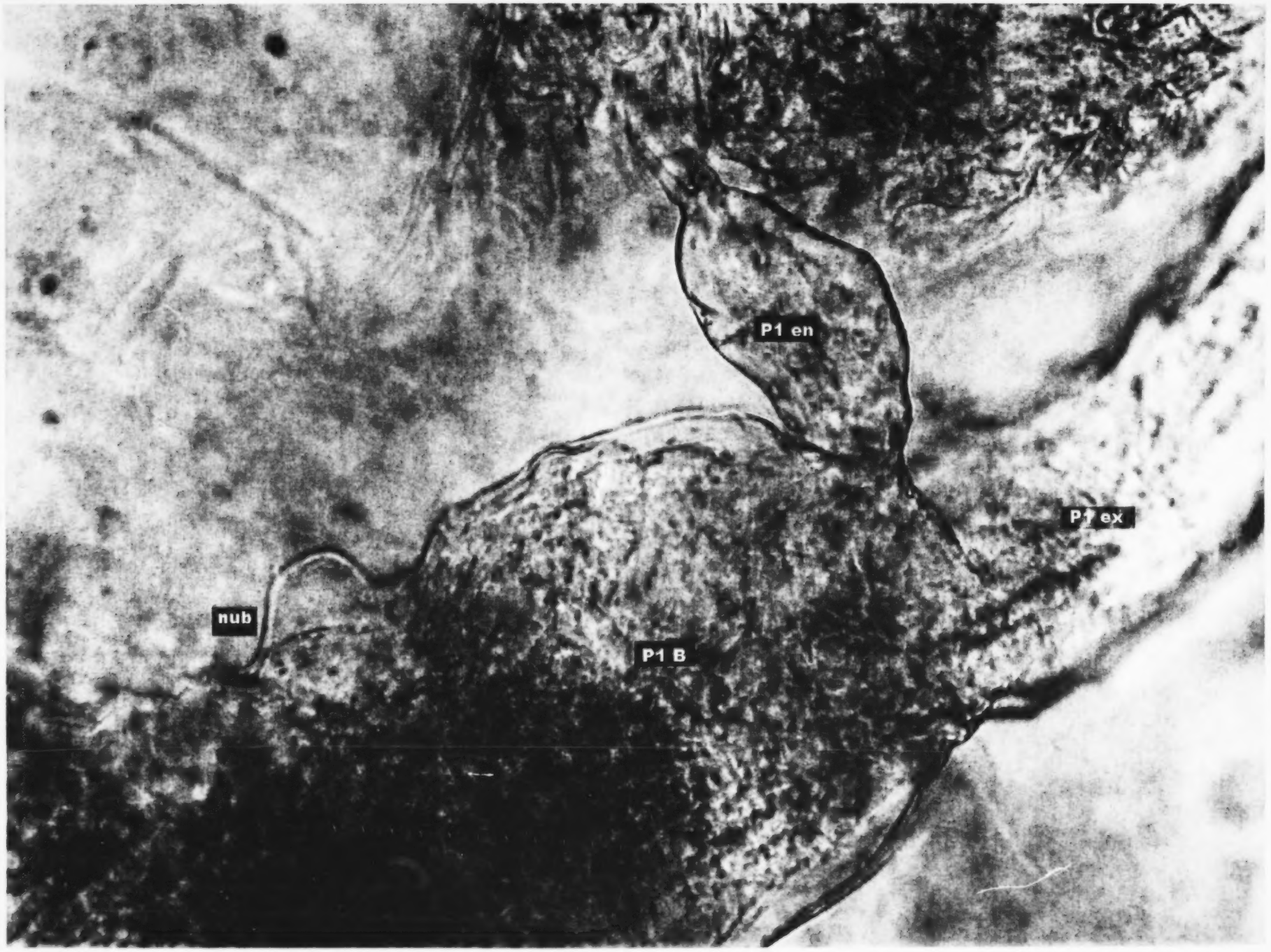

M-P
A2
P2
CR


Nub
nub
P2 B
P1 B

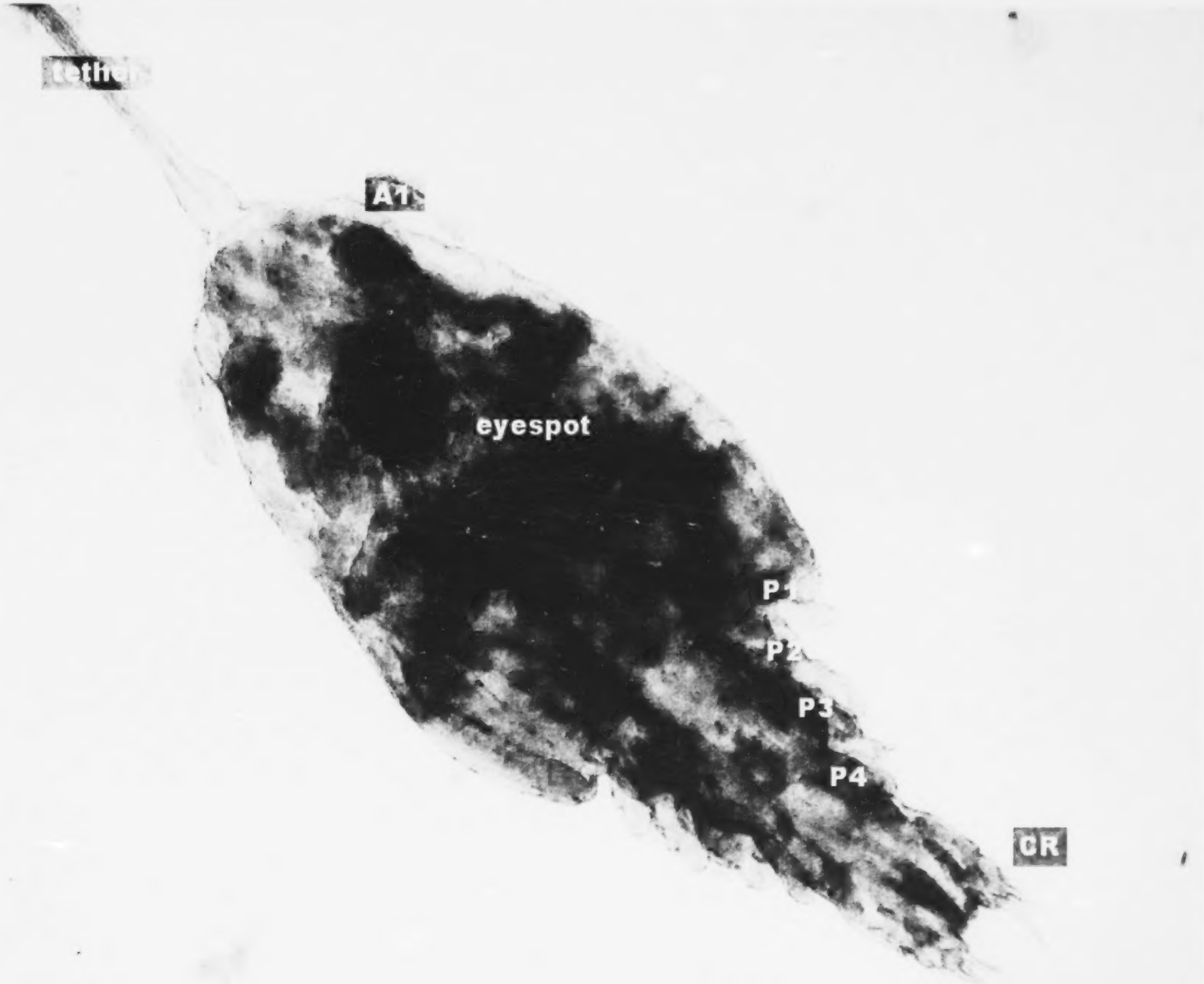

P1
P2
P3
P4
nub
nub
P1 B


P1 en
P1 B
Hub


nub
P2 B
P1 B

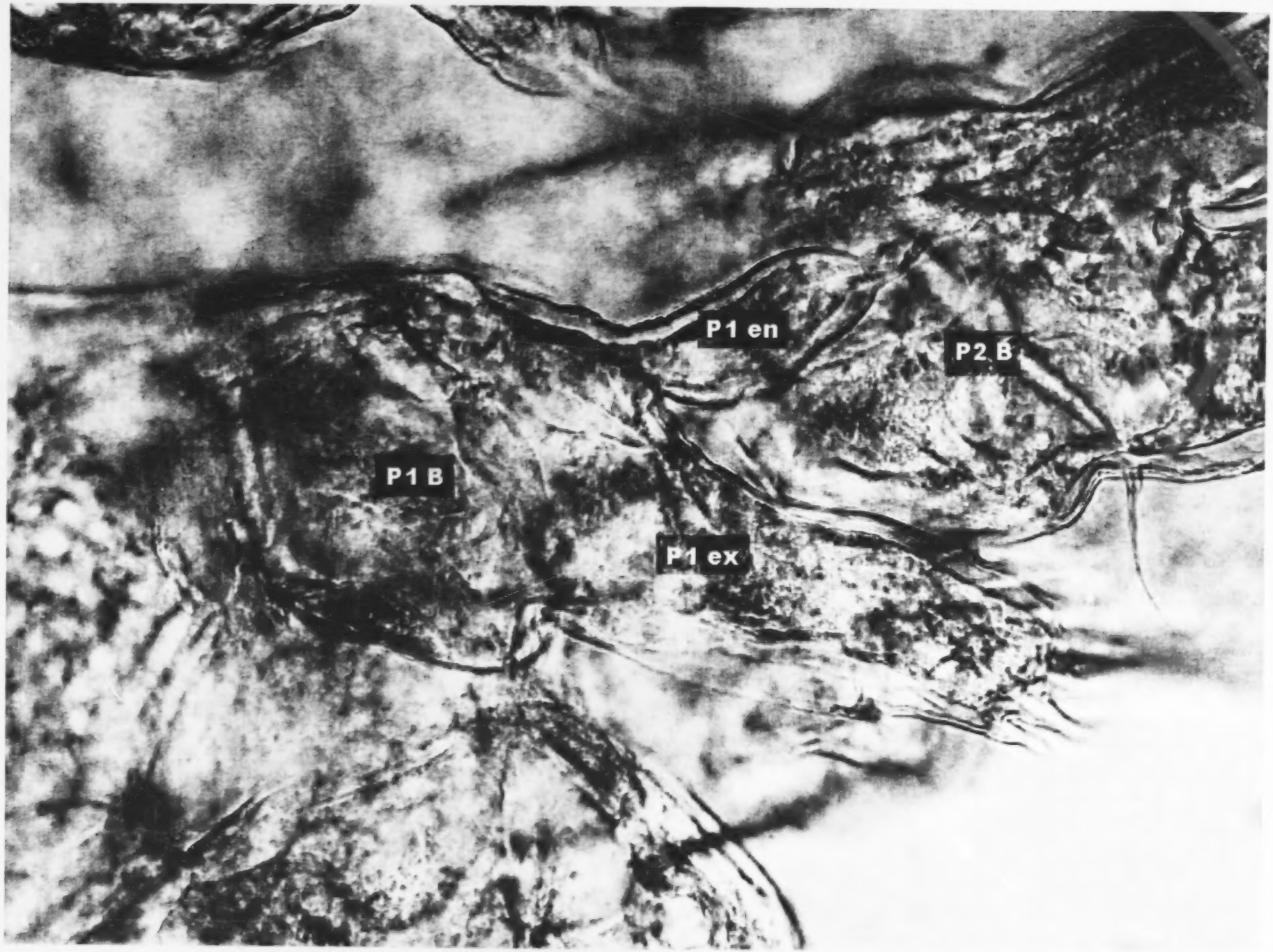

P1 en
P1 ex
nub
P1 B

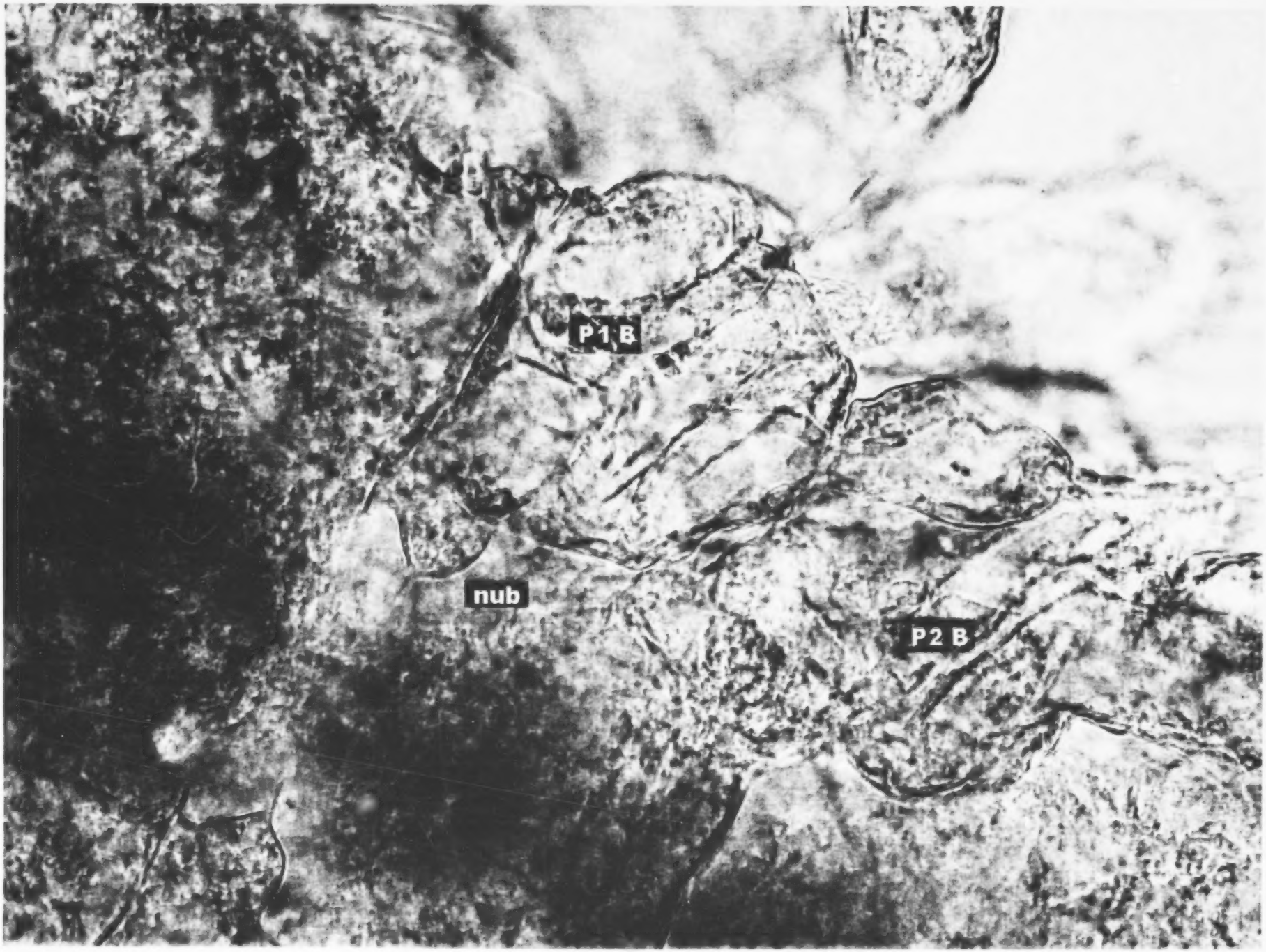
MC
A2
Max 2
tether
Mxp
P1
P2
P3

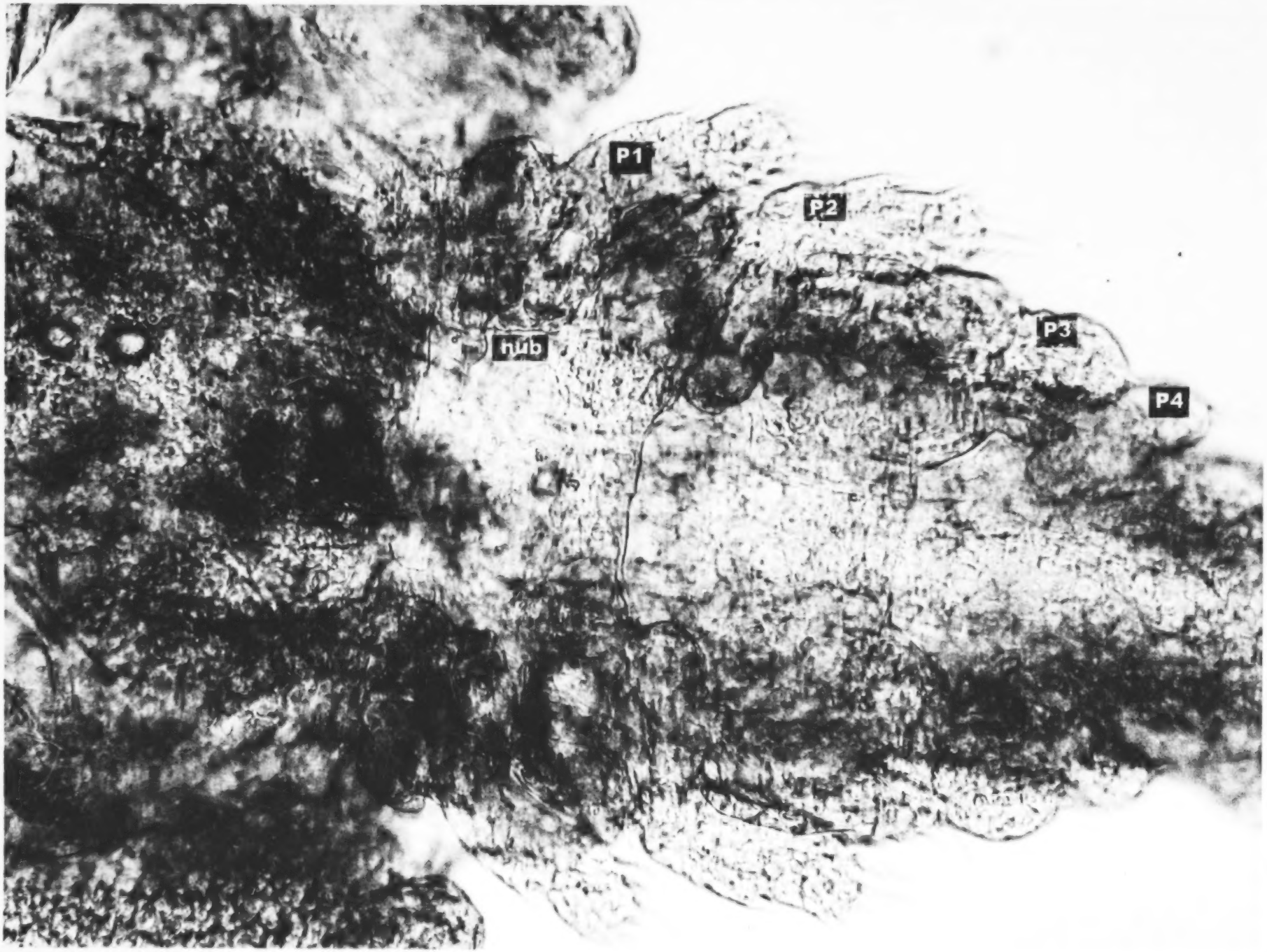

tether
A1
eyespot
P1
P2
P3
P4
CR

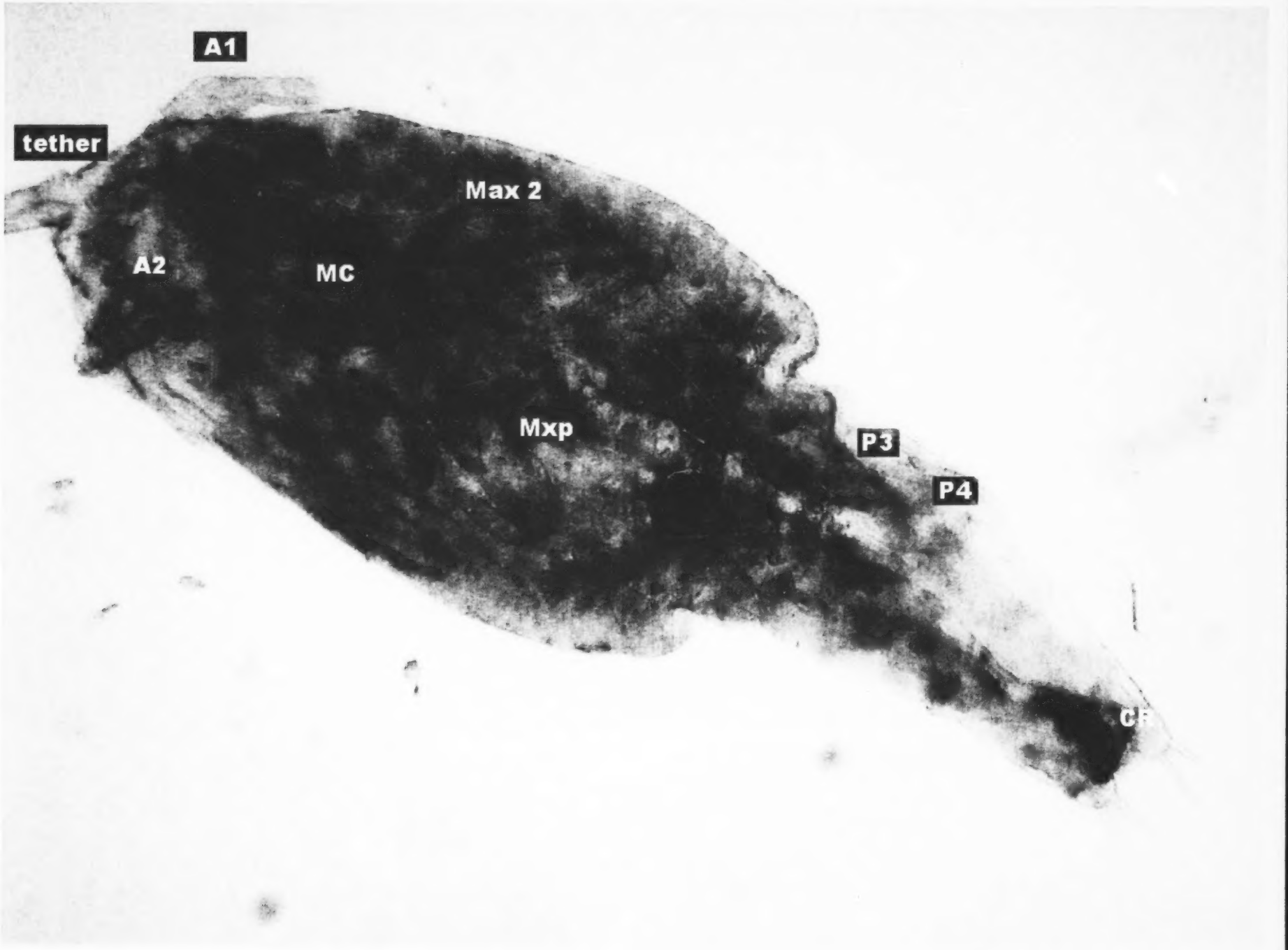
P1 ex
P1 en
P1 B
P2 B
oub

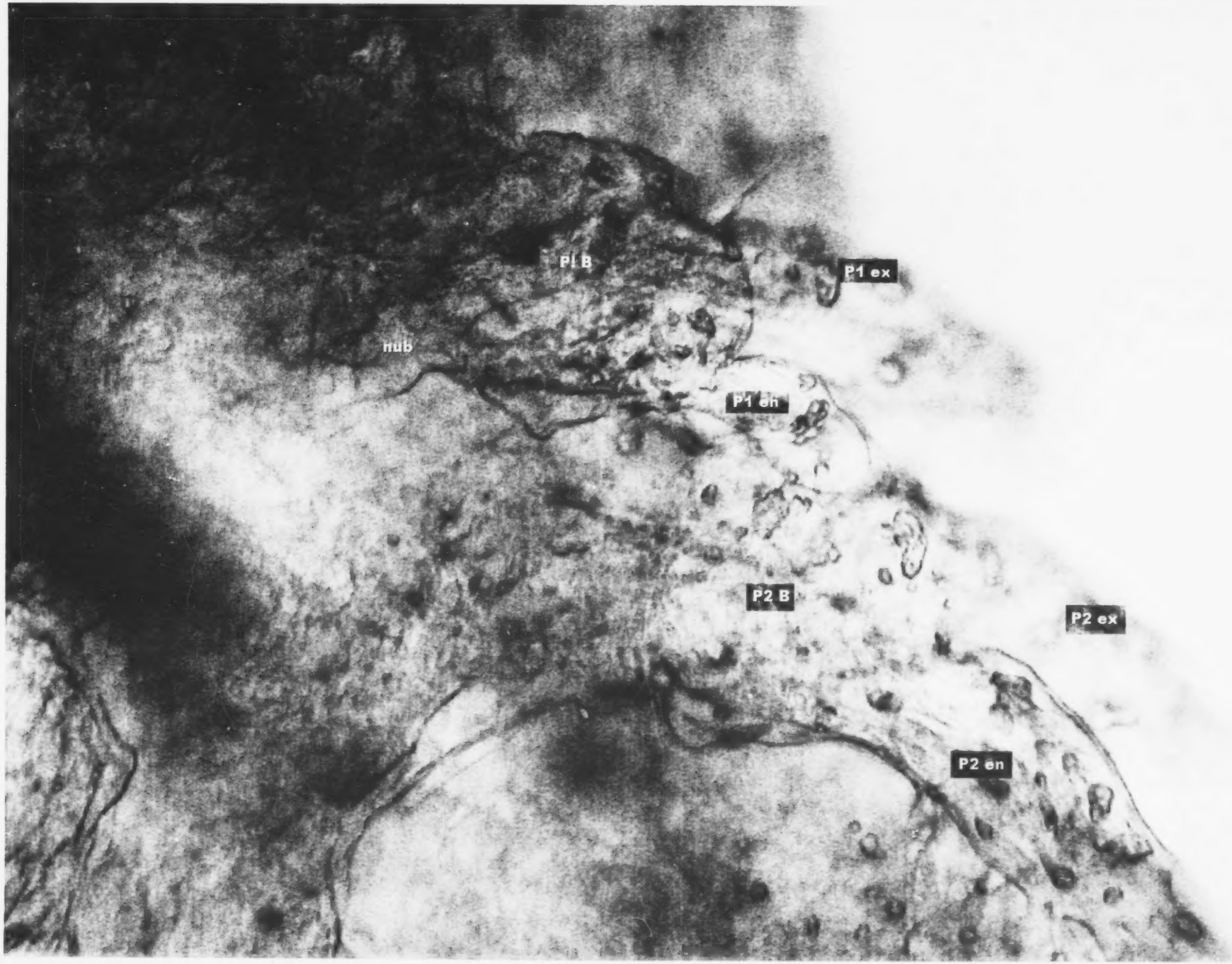
P2 B
P1 en
P1 ex
P1 B
nub

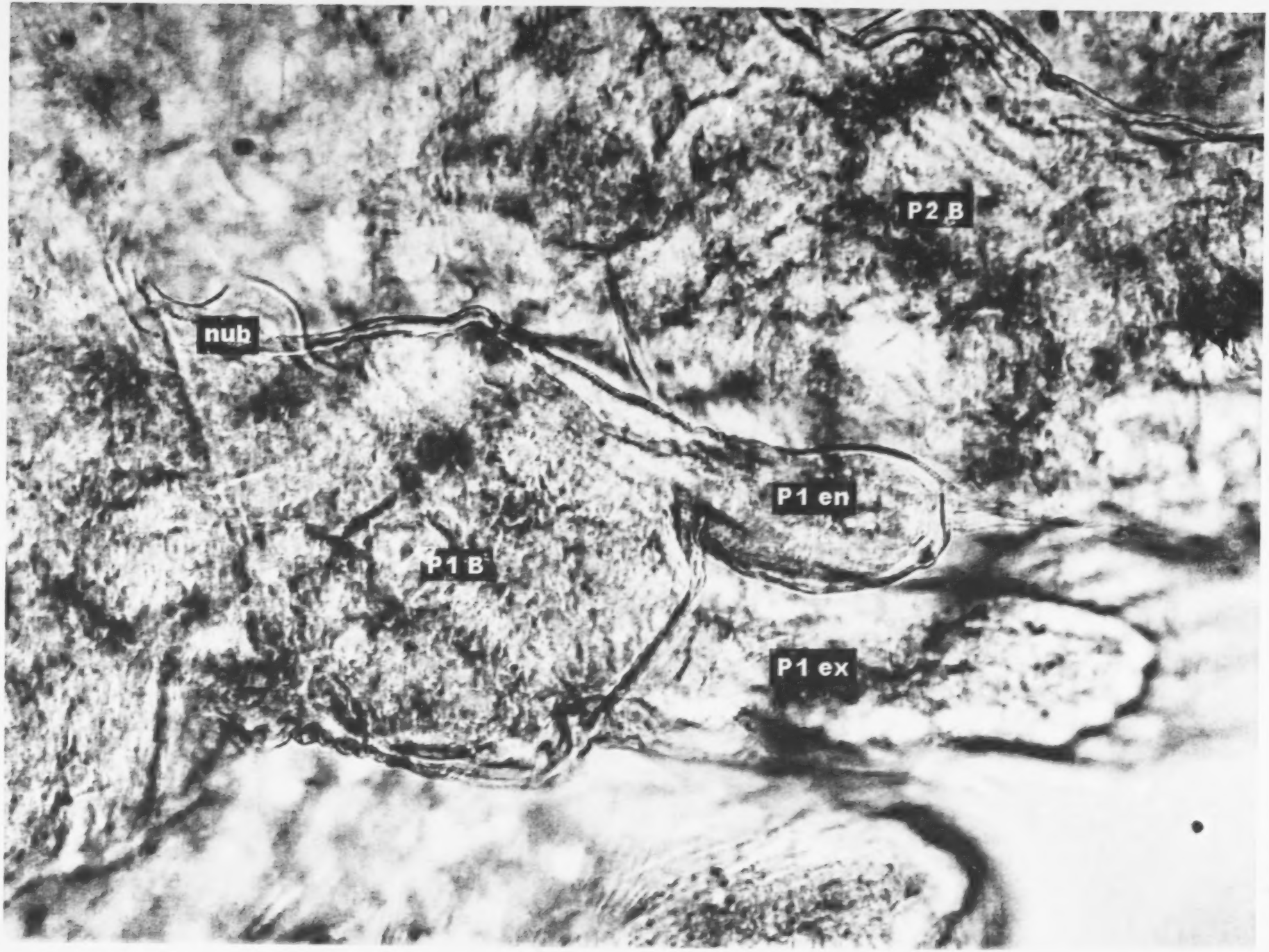

P1 en
P2 B
P1 B
P1 ex

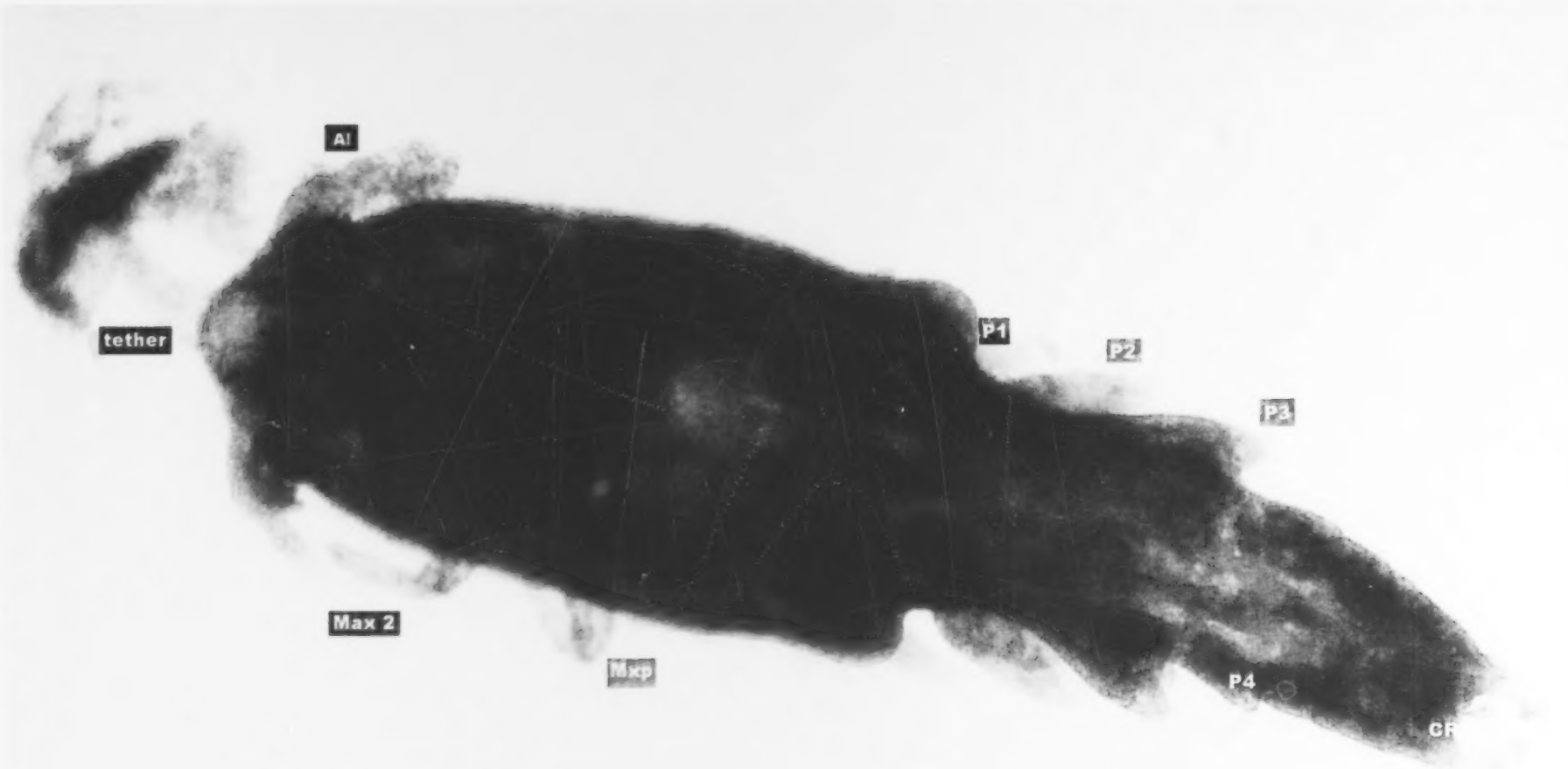

P1 B
nub
P2 B

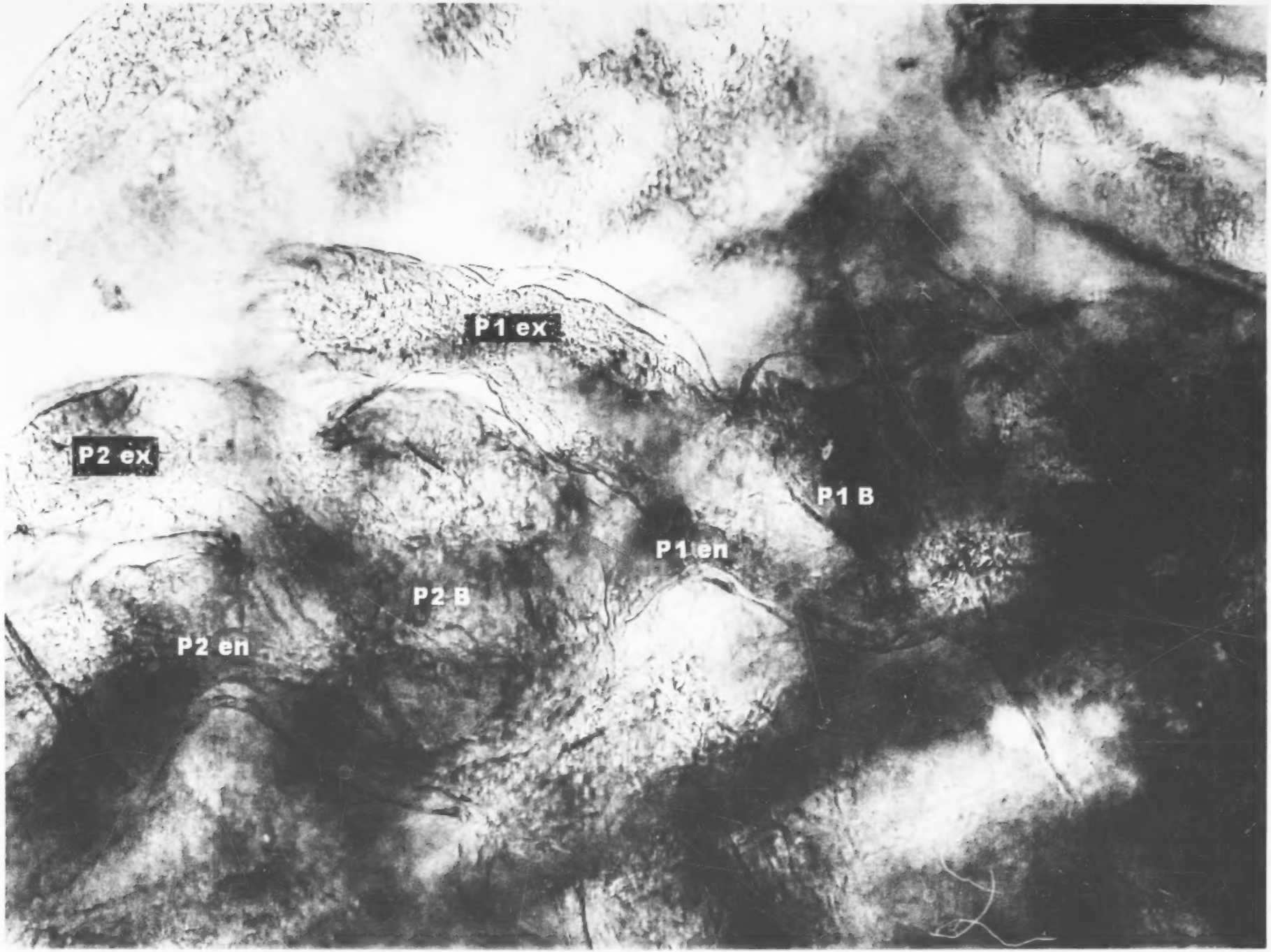

P1
P2
P3
P4
hub

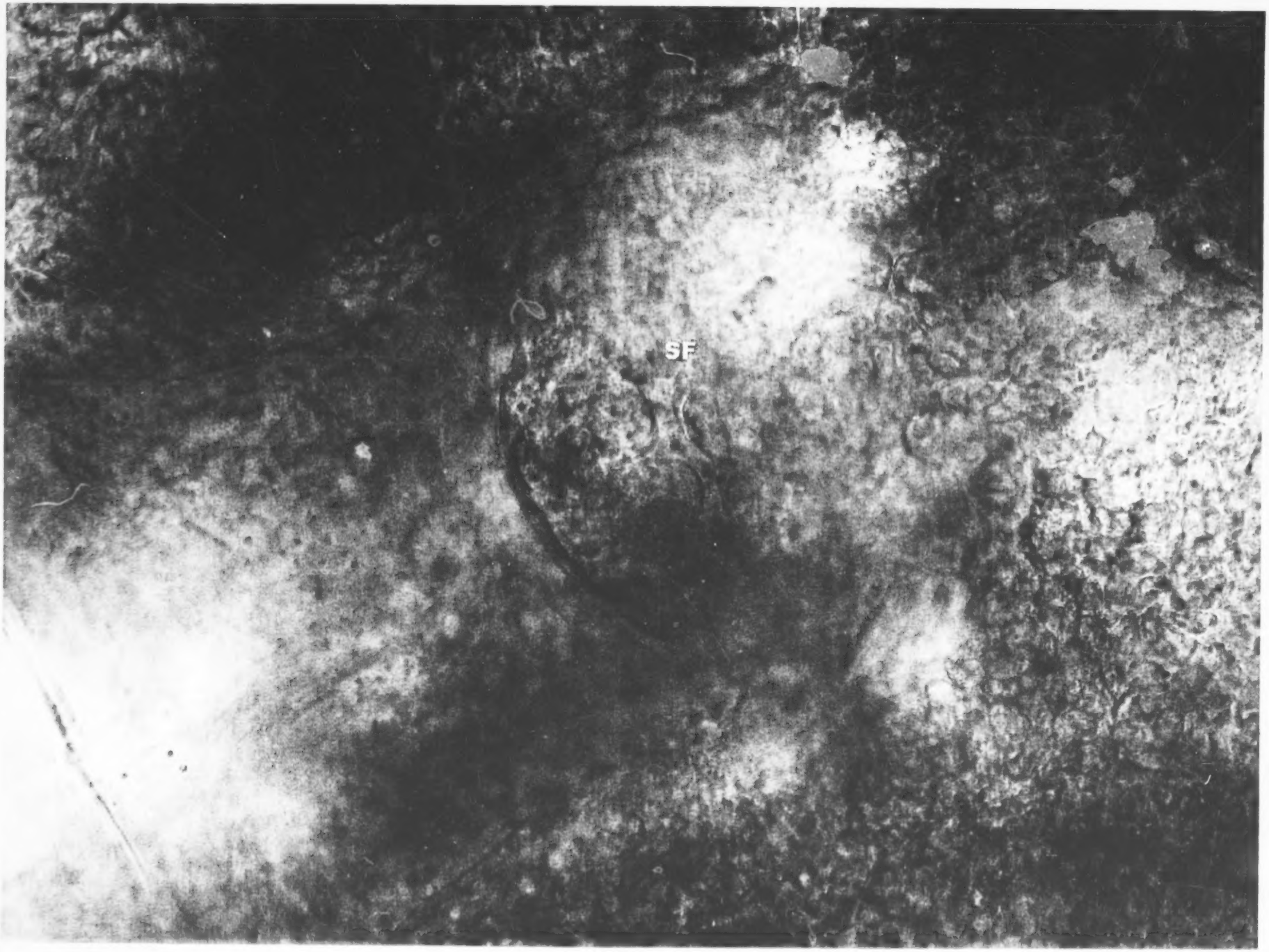

A1
tether
Max 2
A2
MC
Mxp
P3
P4
CR


P1 B
P1 ex
hub
P1 en
P2 B
P2 ex
P2 en


P2 B
nub
P1 en
P1 B
P1 ex


A!
tether
P1
P2
P3
Max 2
Mxp
P4


P1 ex
P2 ex
P1 B
P1 en
P2 B
P2 en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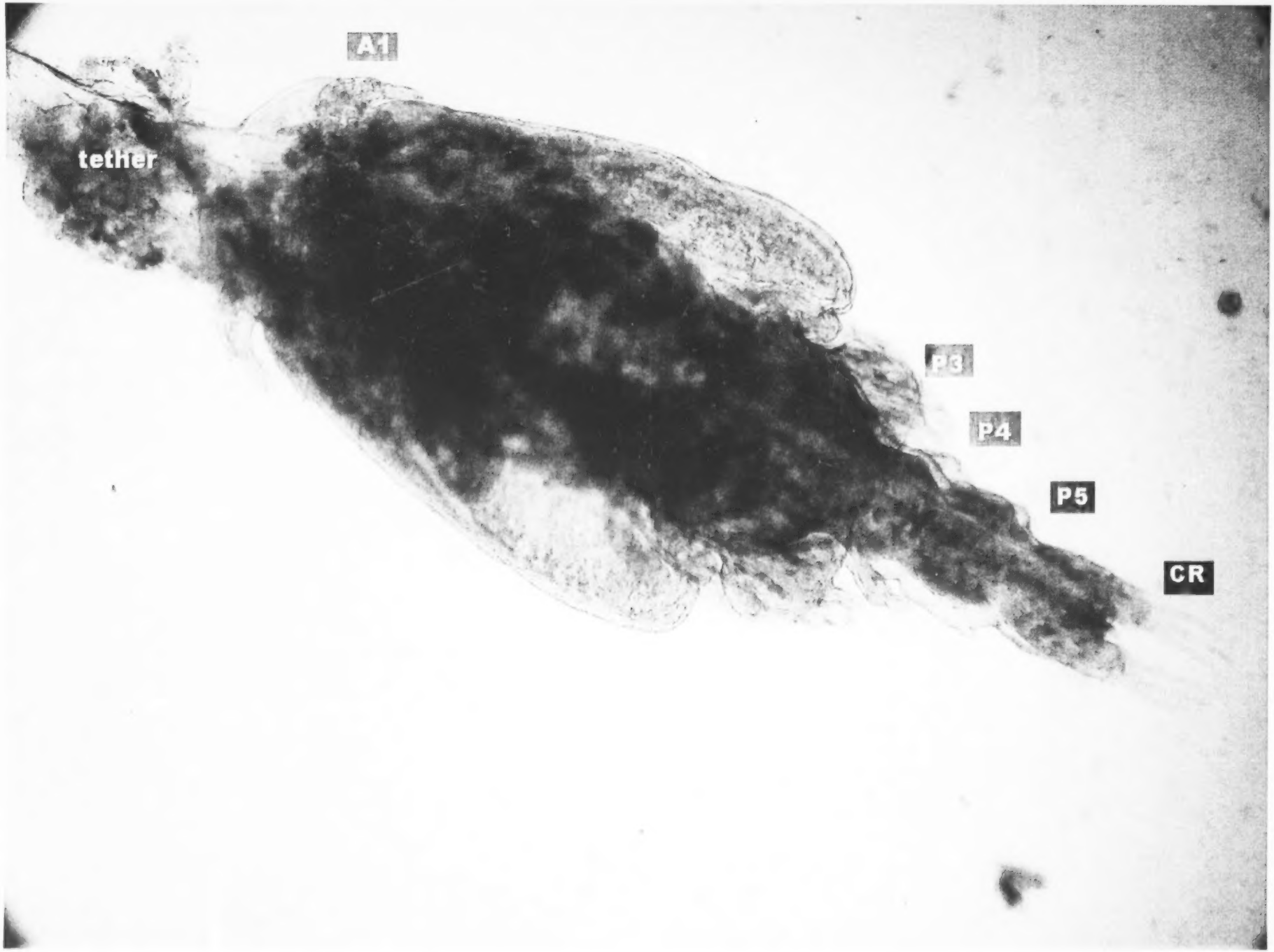
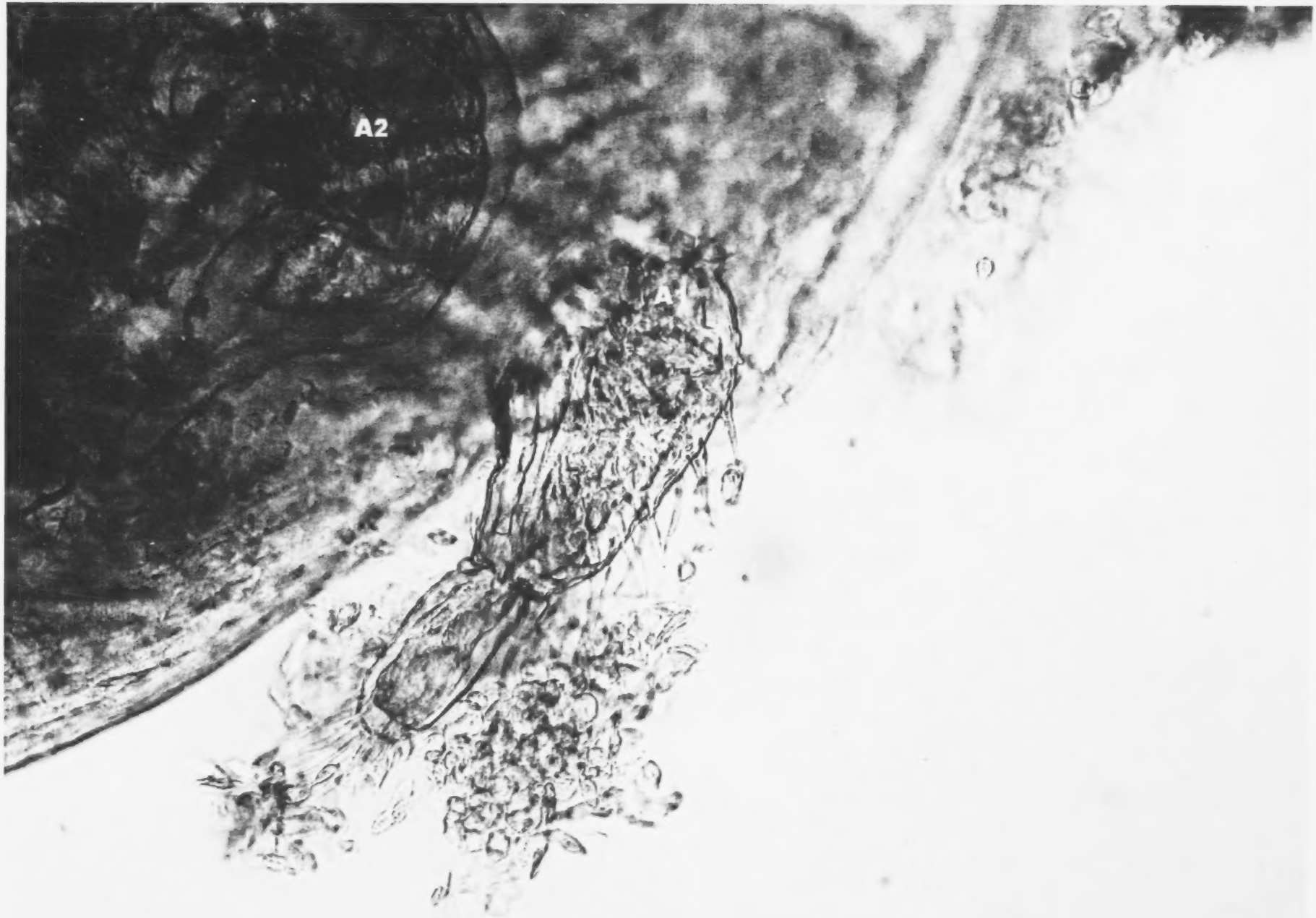

A1
tether
P3
P4
P5
CR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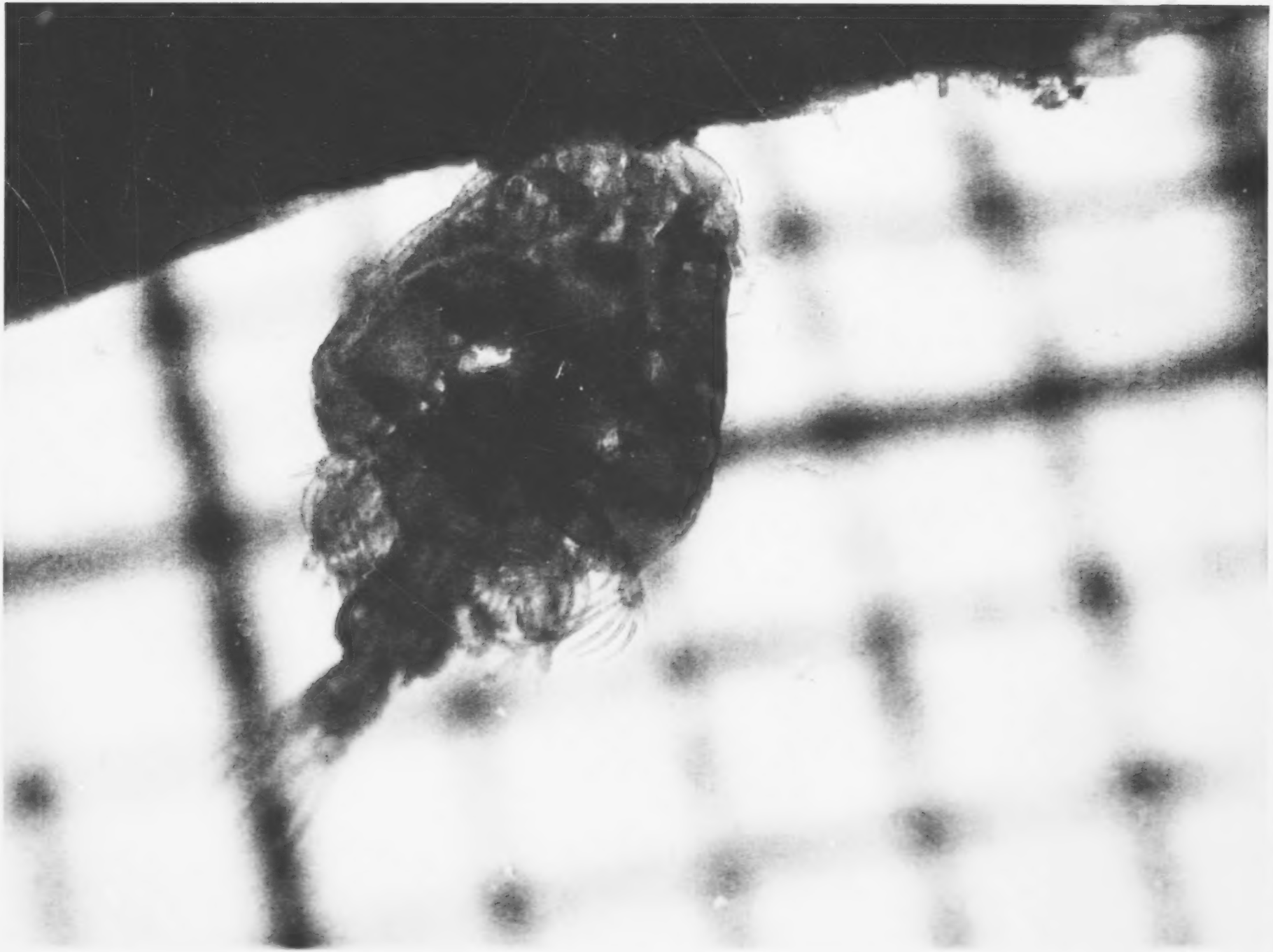

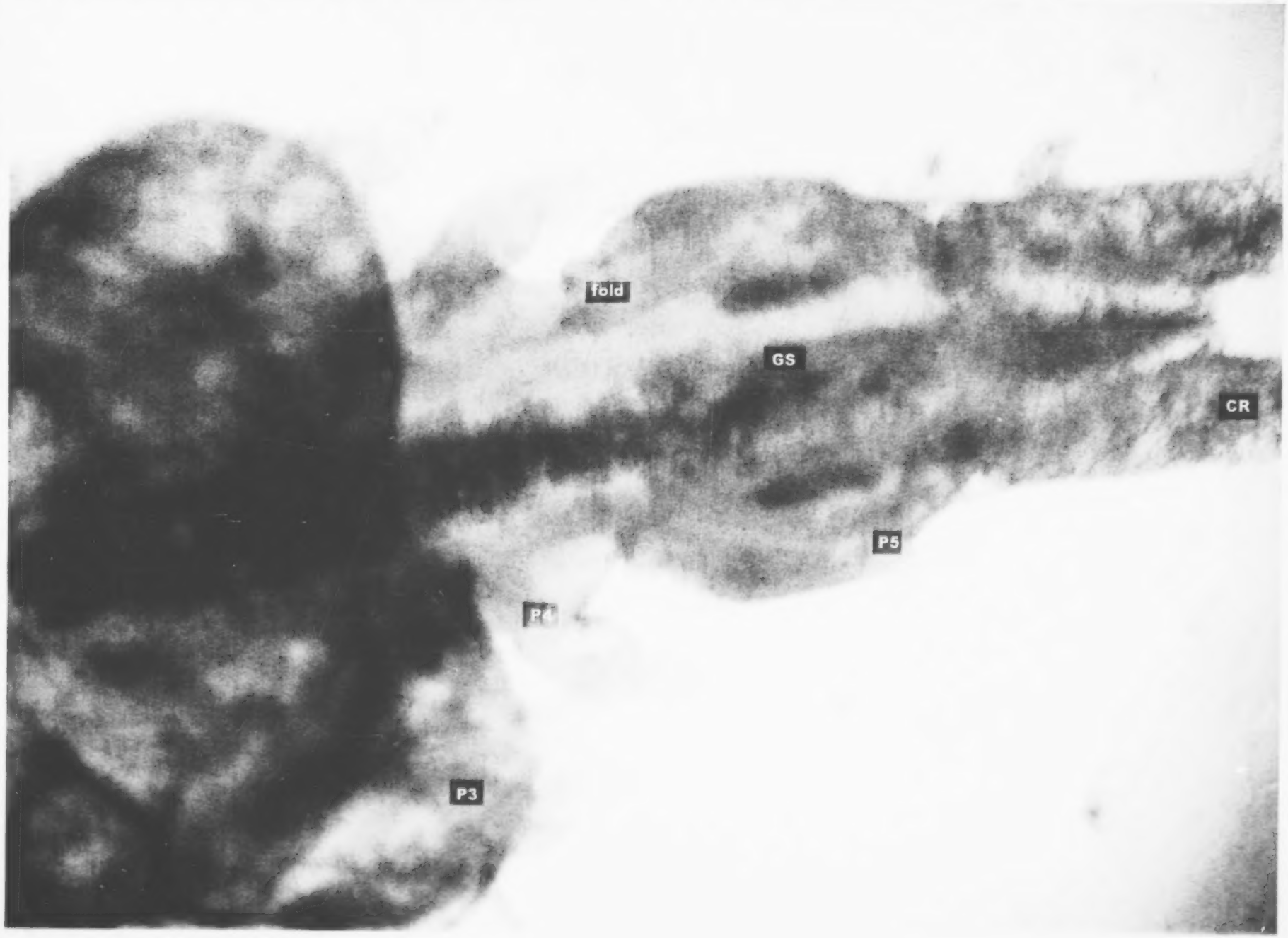
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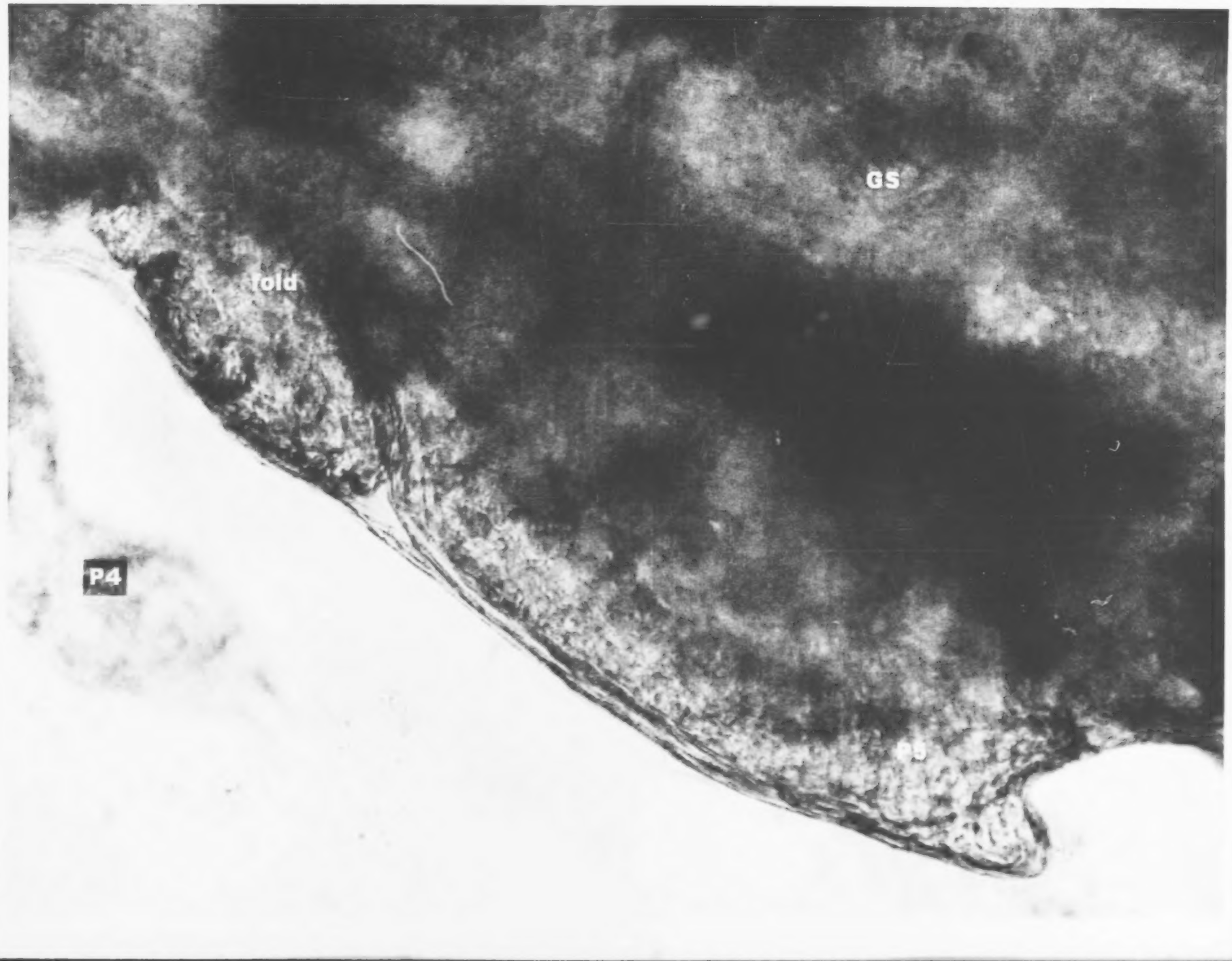
GS
CR
P5
P4
P3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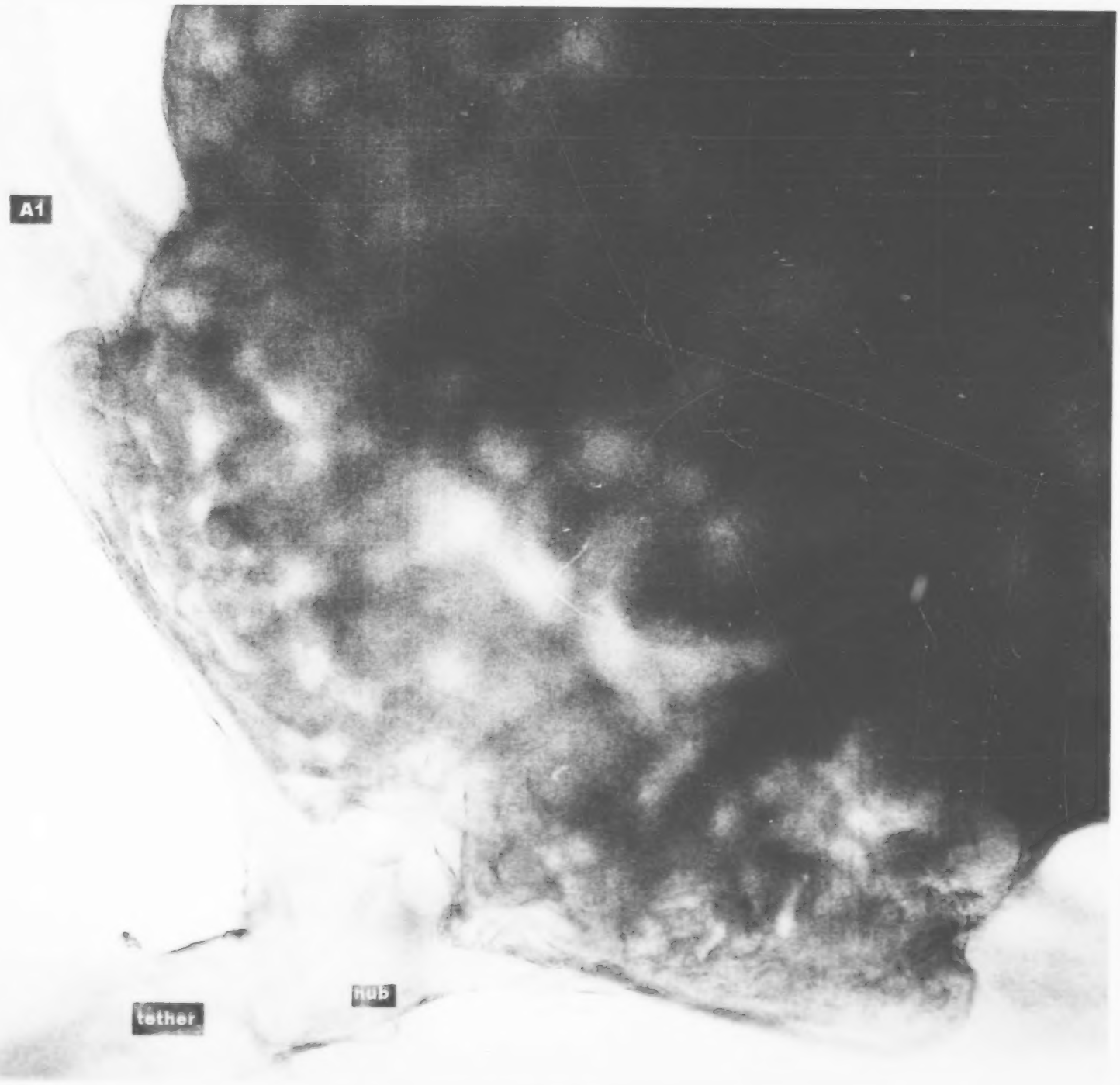
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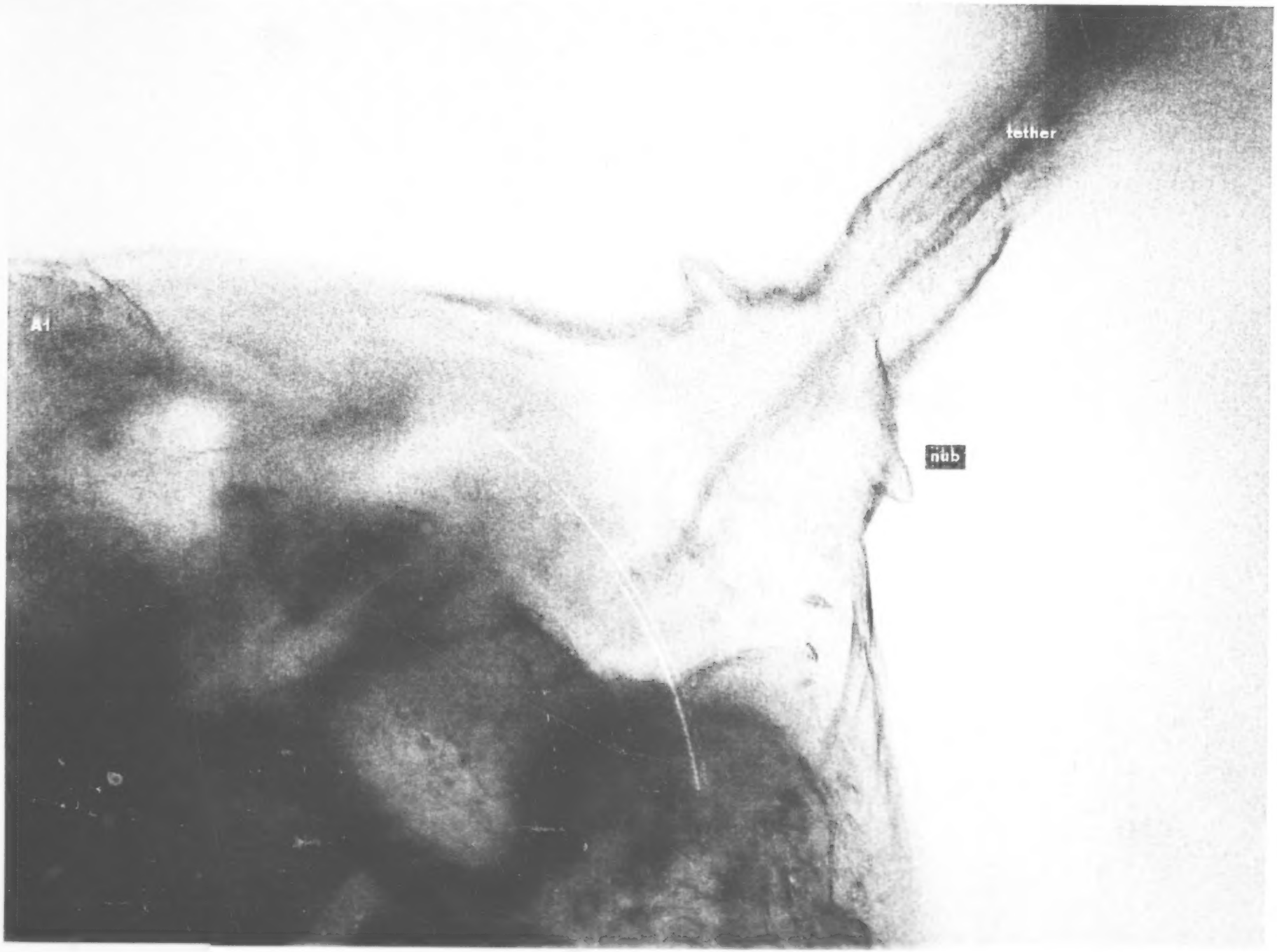
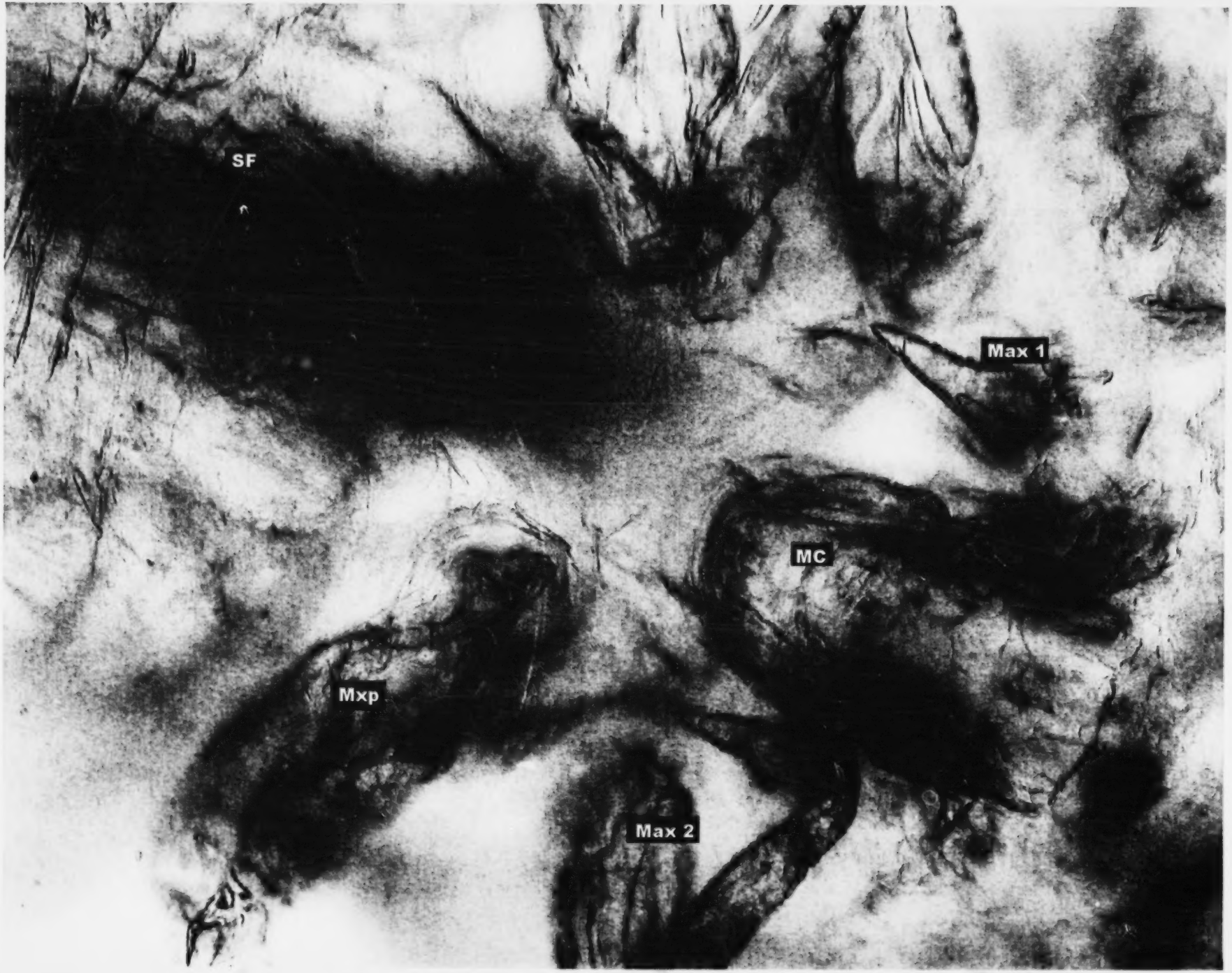

tether
A1
nub

A1
tether
A2
Mxp
P1
P2
P3
P4
P5
CR
MC
GS
Max 2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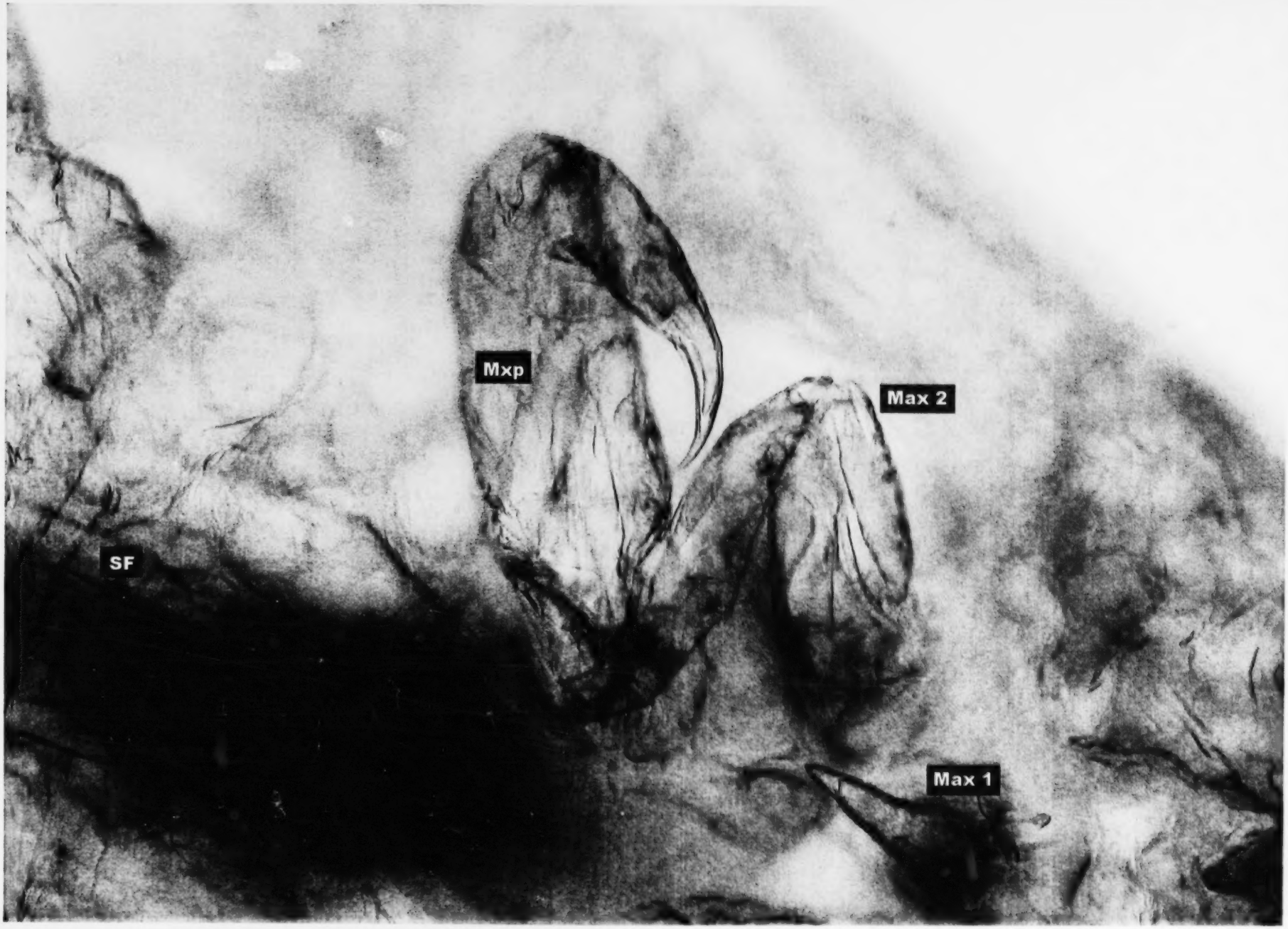
MC
Mxp
Max 2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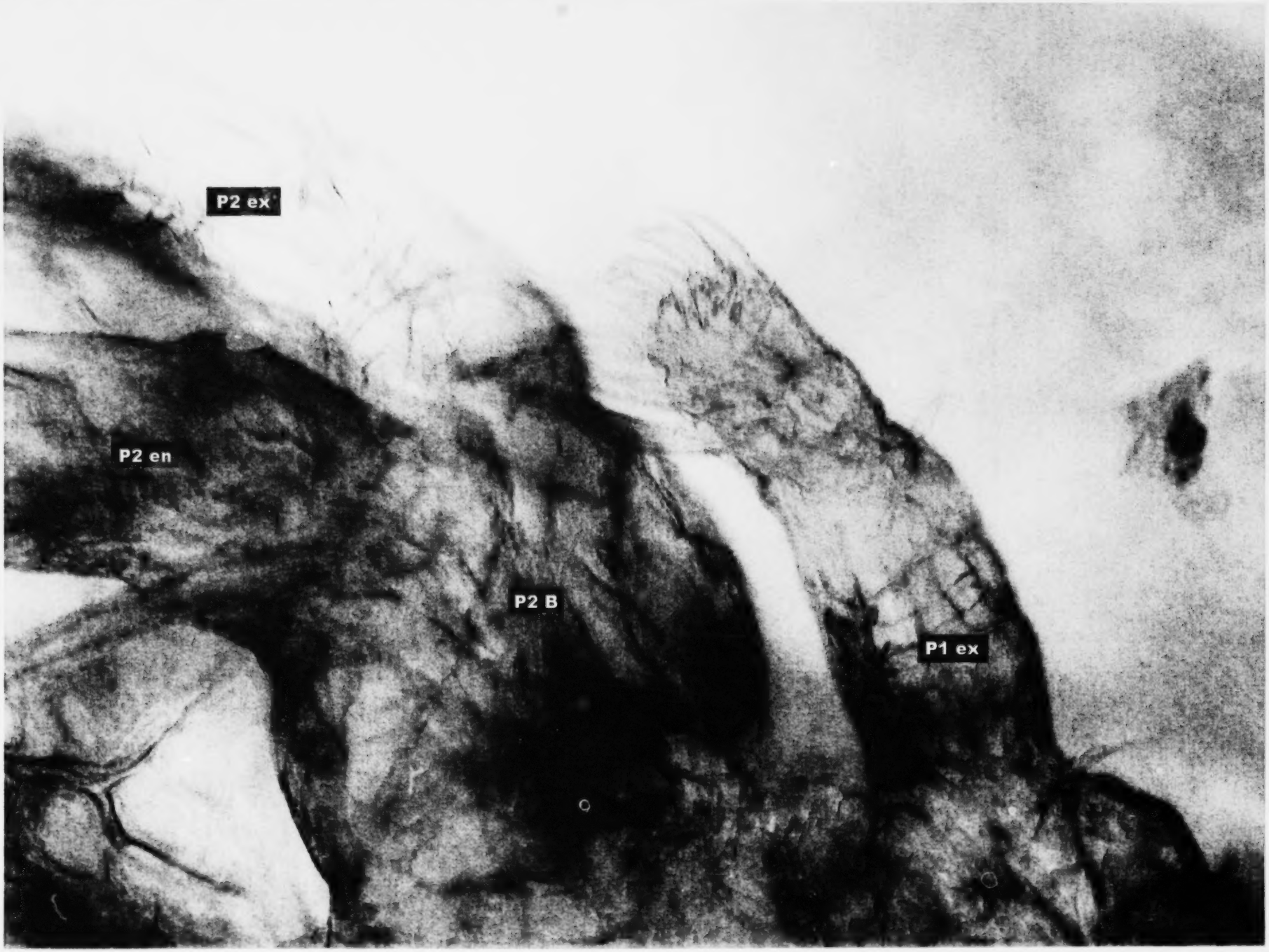
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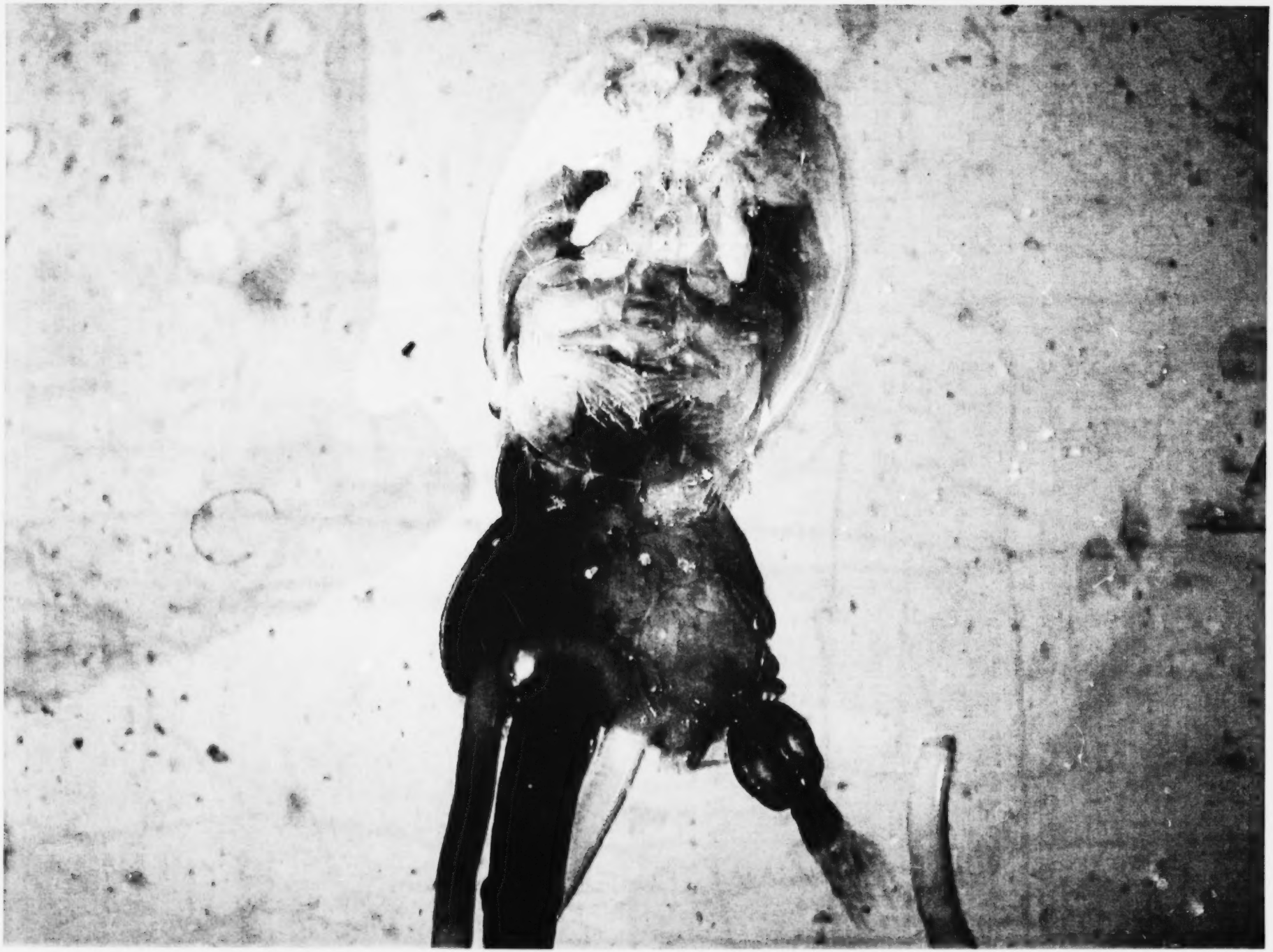
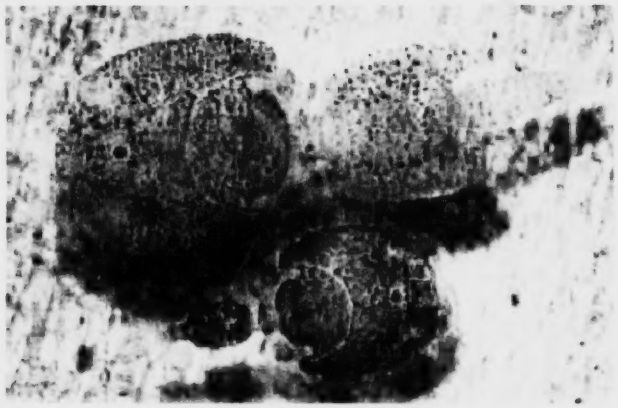
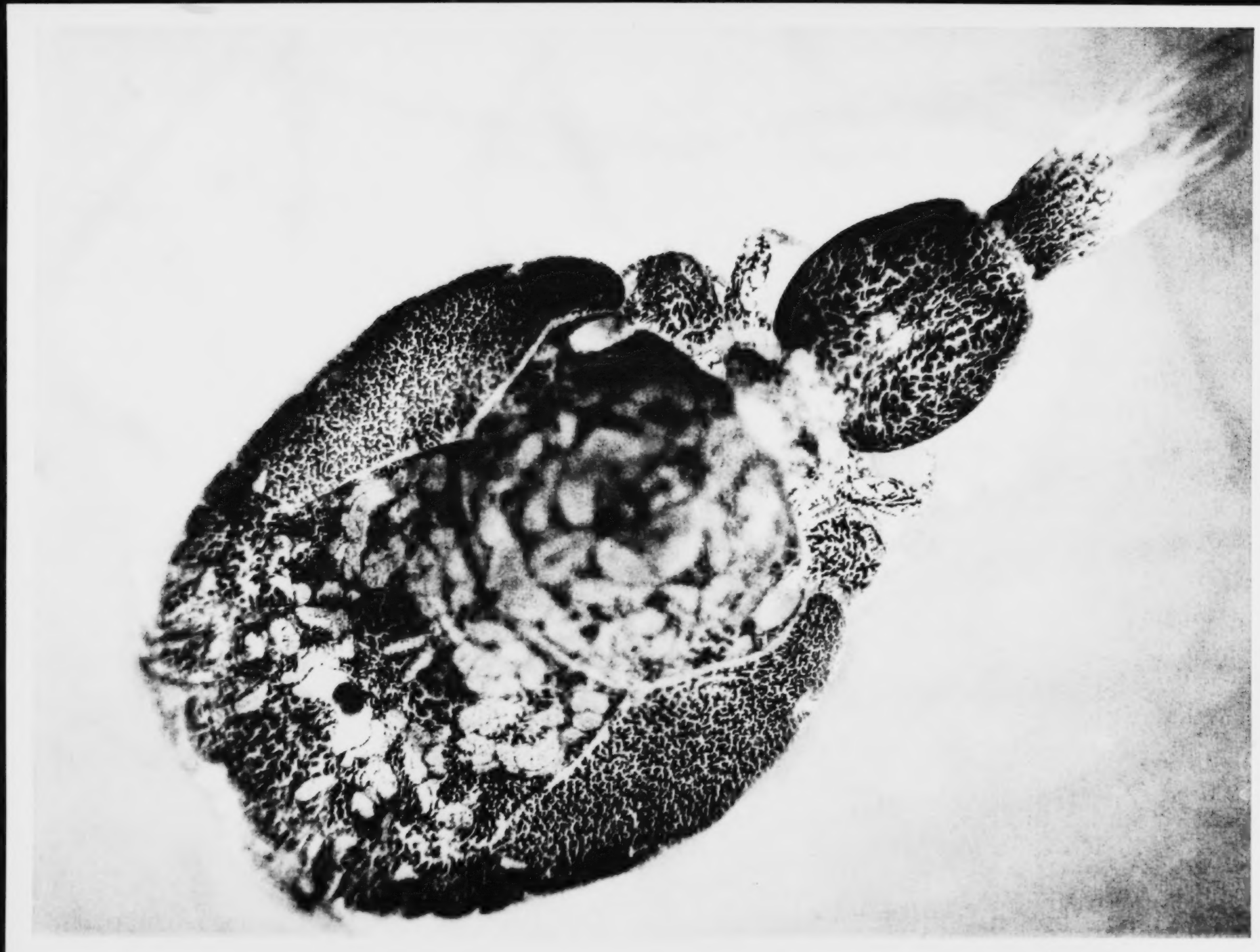
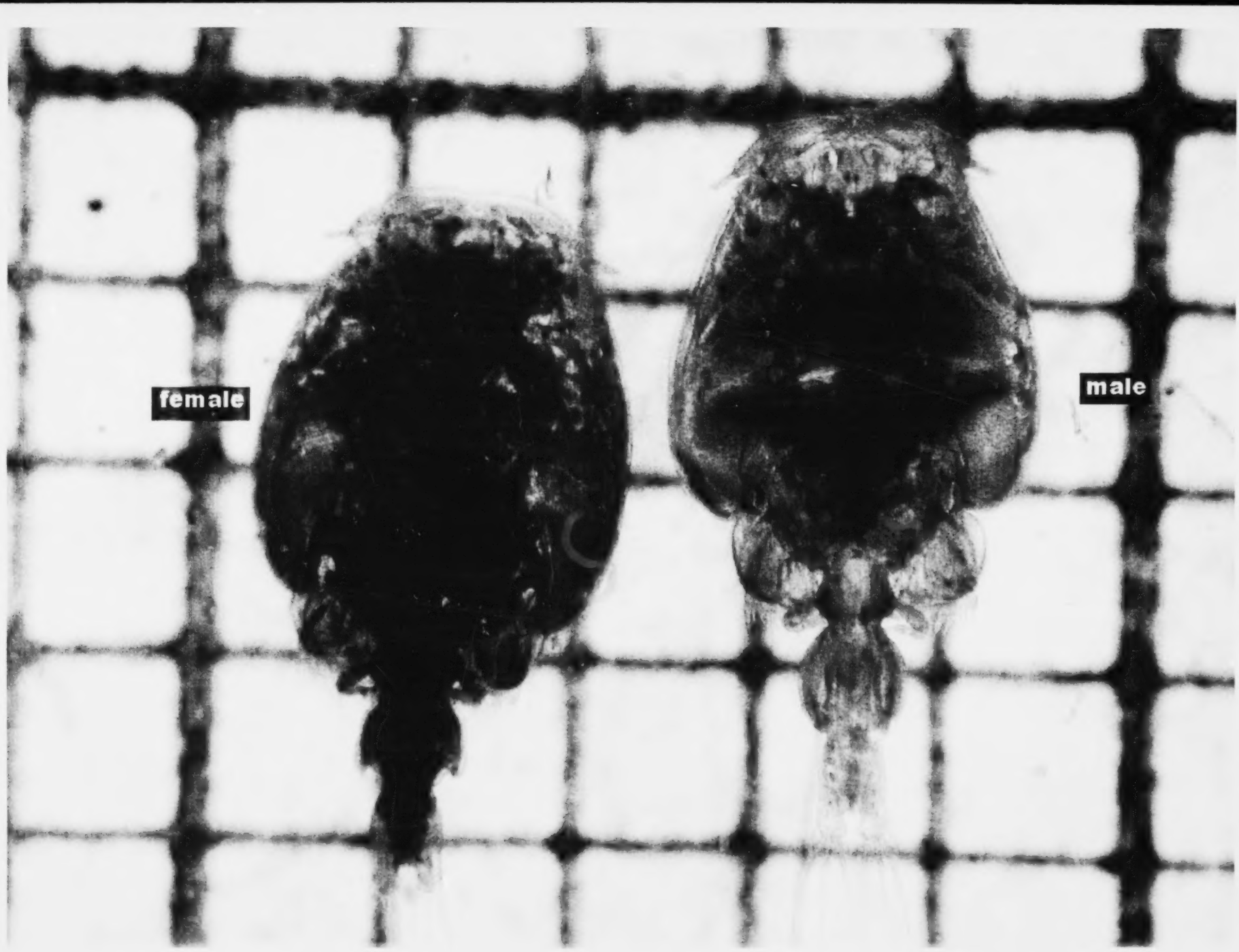
P2 en
P2 B
P1 ex

Mxp
Max 1
MC
SF
Max 2





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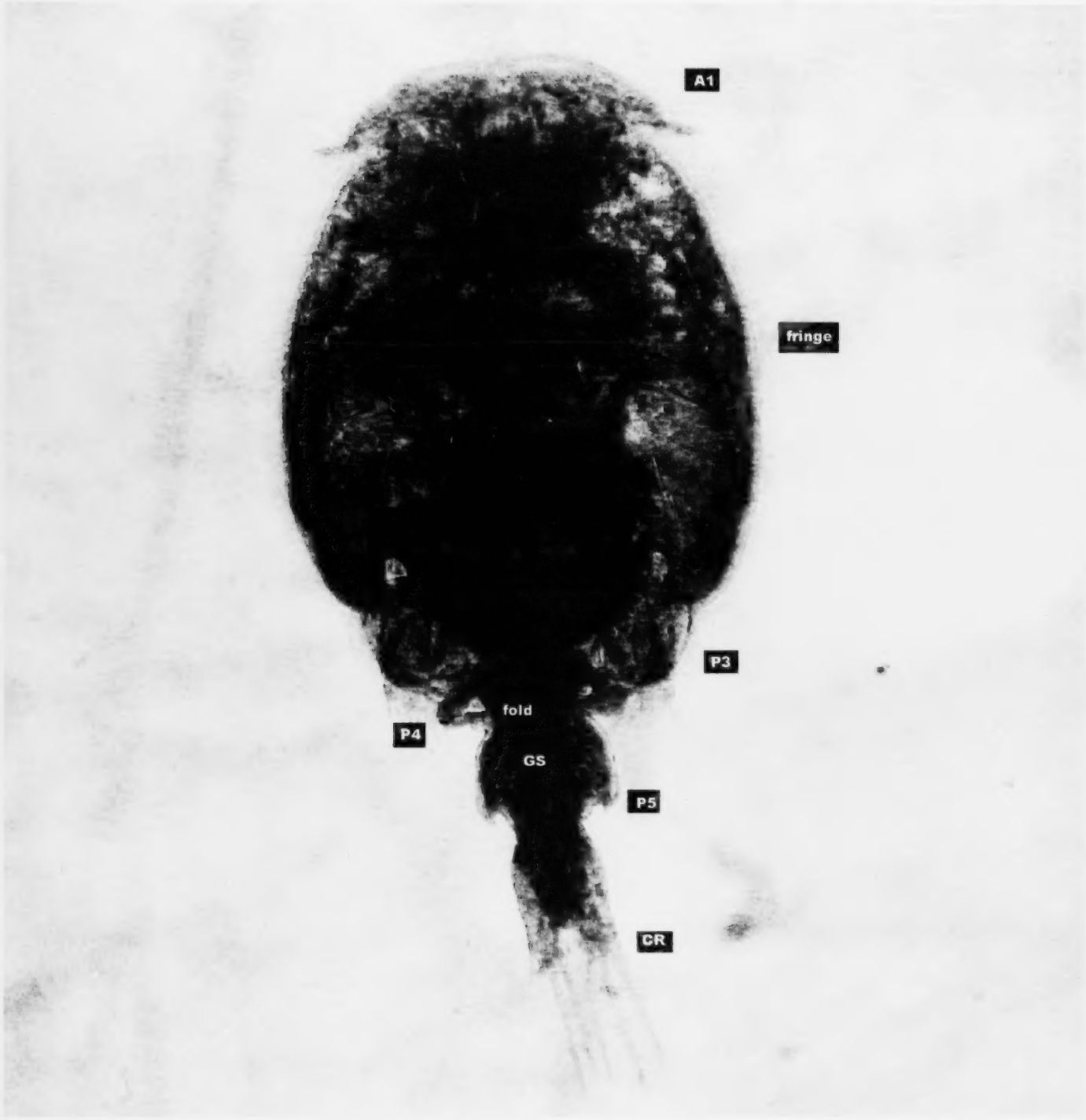
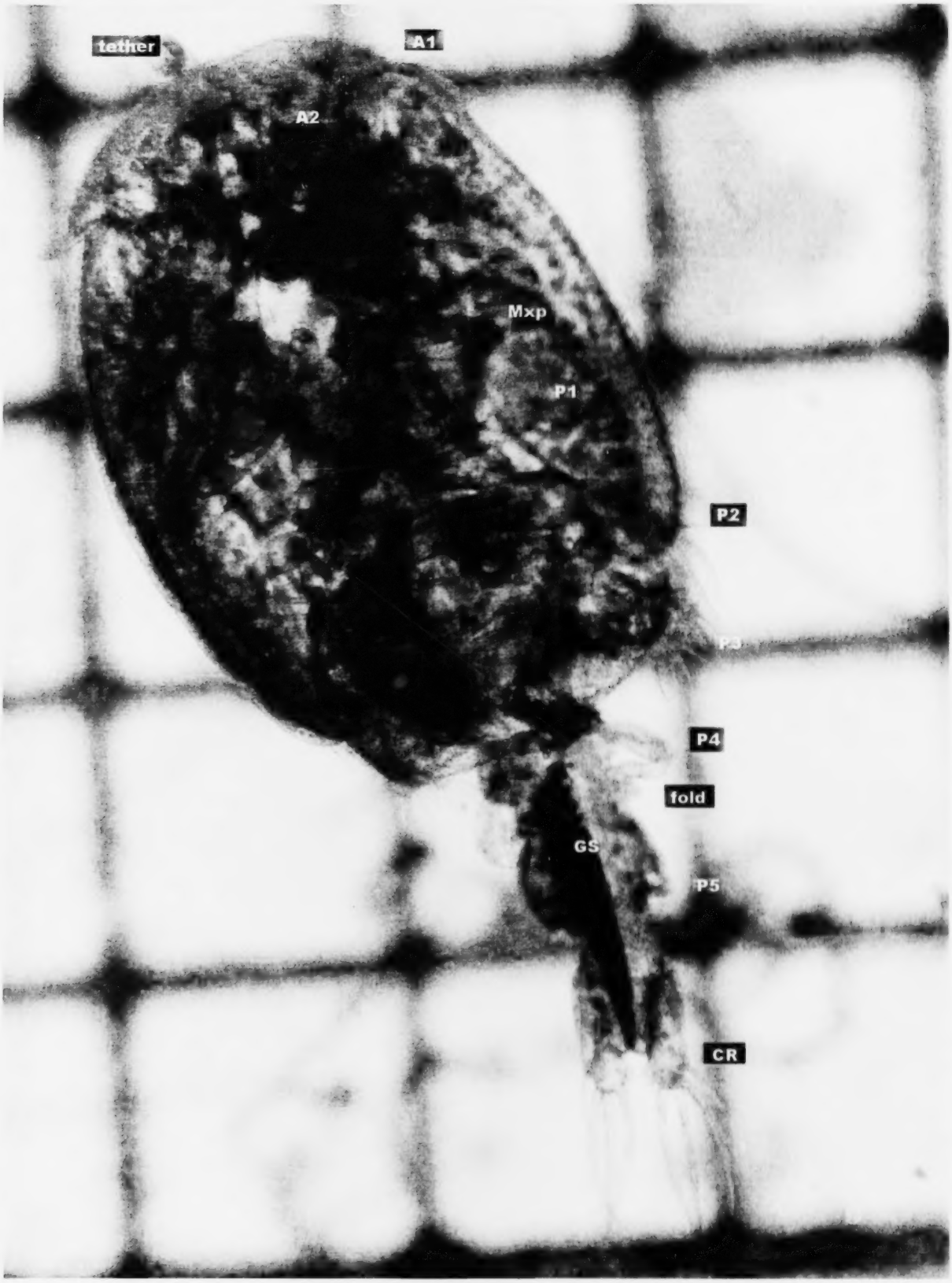
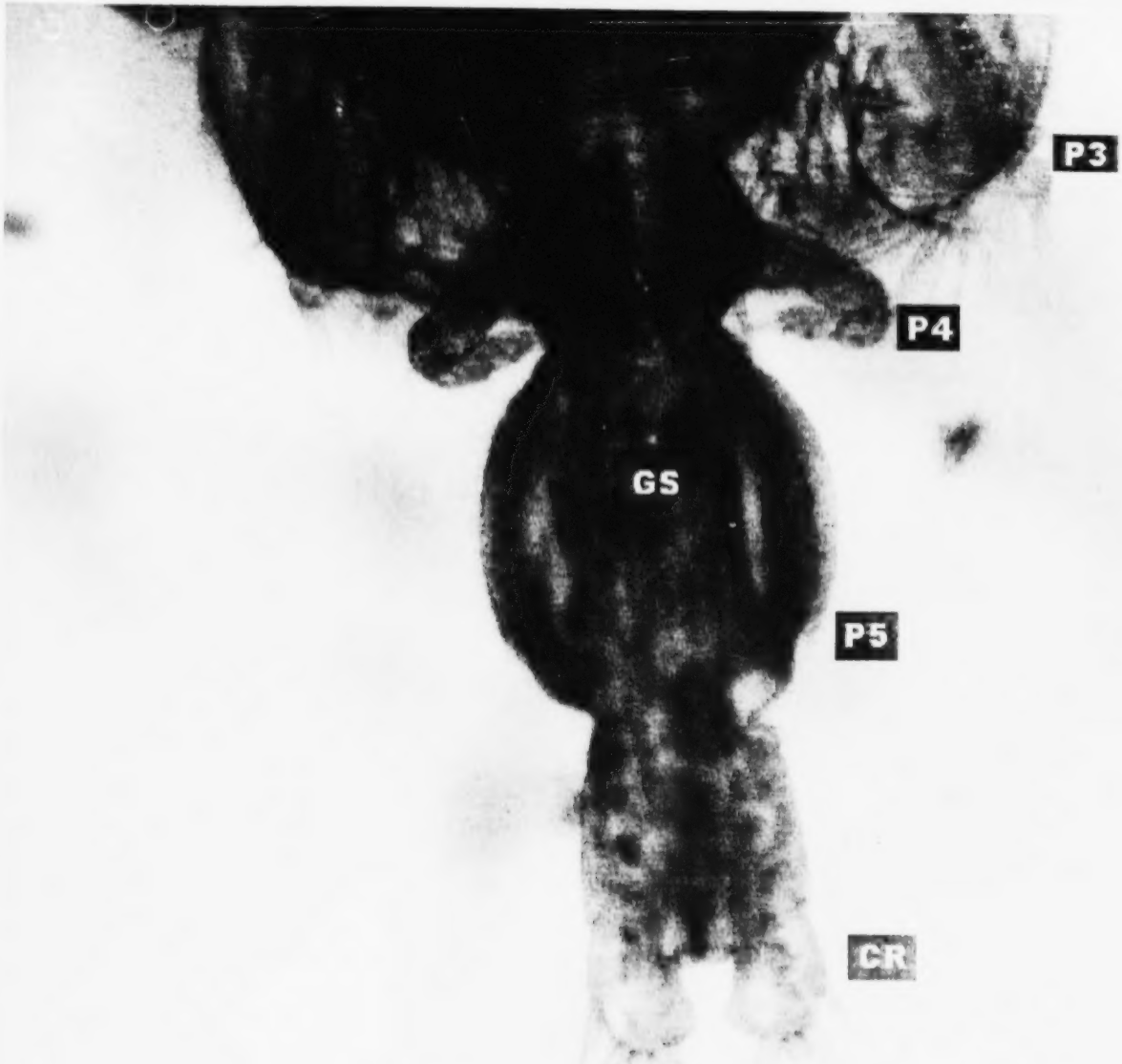

A1
fringe
P3
fold
P4
GS
P5
CR

P3
P4
P5
CR


tether
A1
A2
Mxp
P1
P2
P3
P4
fold
GS
P5
CR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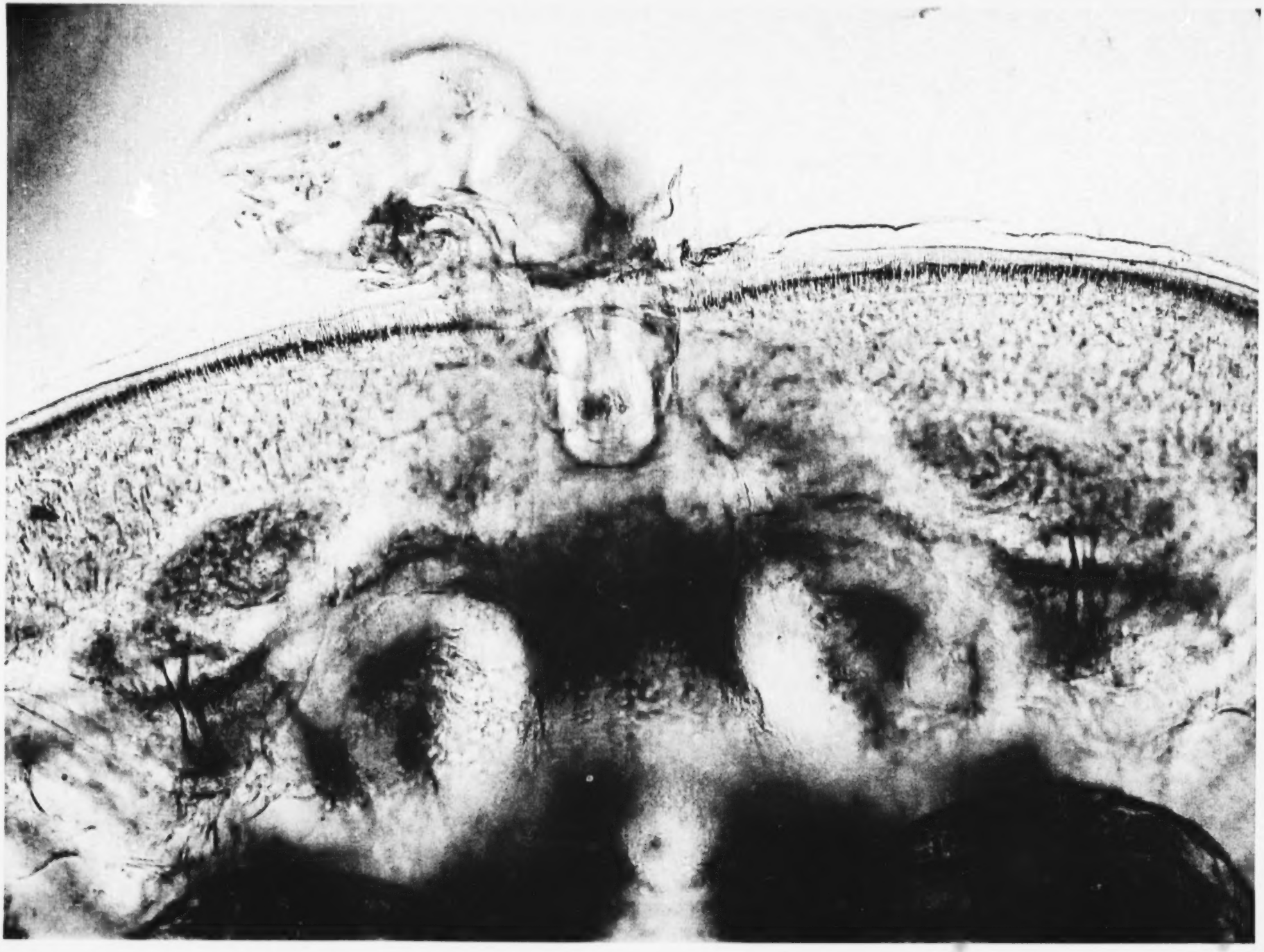
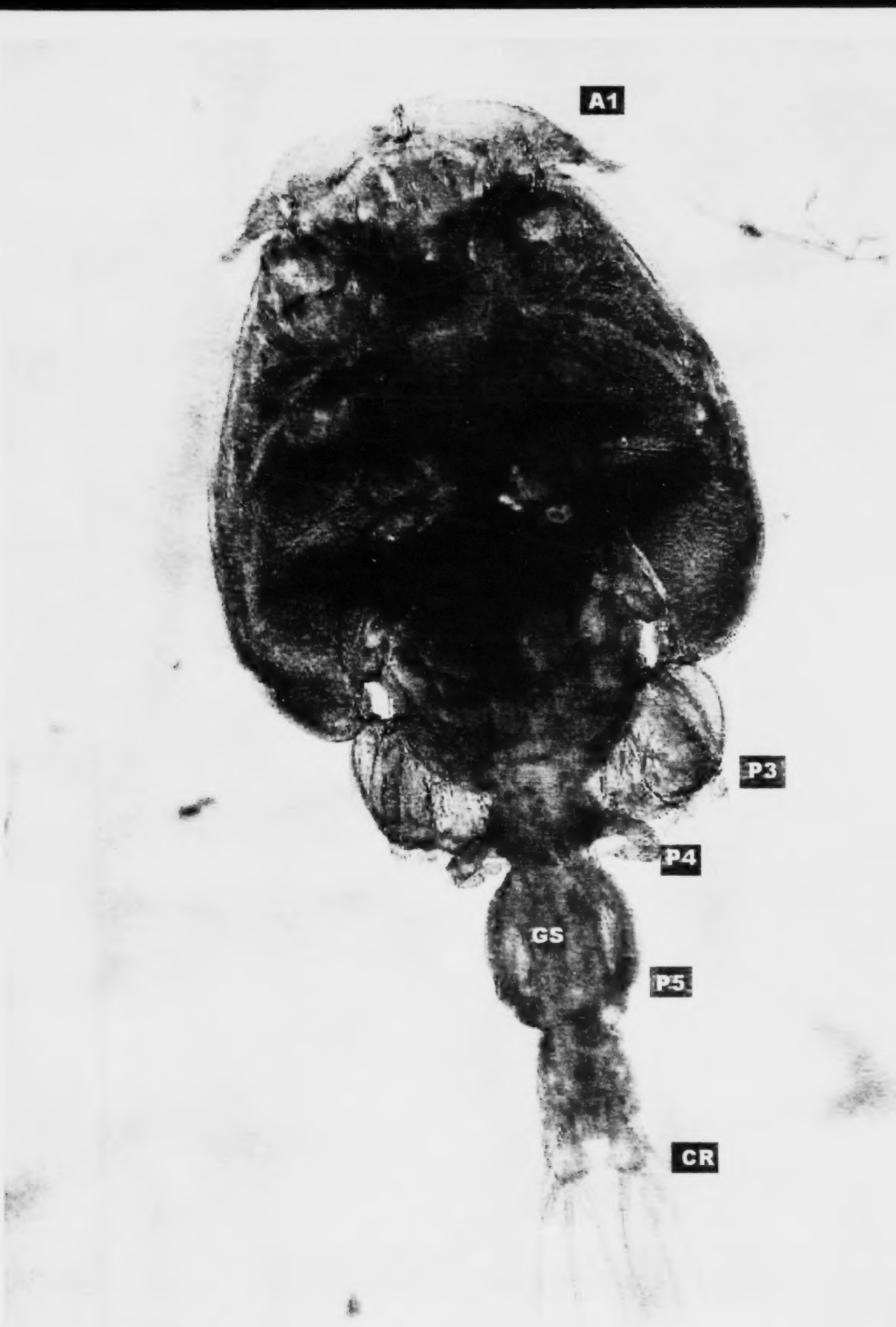
P5
CR




A1
P3
P4
GS
P5
CR

A1
MC
P4
GS
CR

A2
A1

SF
Mach
Mach

P5
P6

drawings

calanoid nauplii.jpg

clemch1 kabata.jpg

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clemch1 p1 end1.jpg

clemch1 p1 end3.jpg

clemch1 p1 kabata.jpg

clemch1 p1.jpg

clemch1.jpg

clemch2 kabata.jpg

clemch2 p1 kabata.jpg

clemch2 p1.jpg

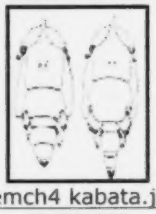
clemch2.jpg

clemch3 kabata.jpg

clemch3 p1 kabata.jpg

clemch3 p1.jpg

clemch3.jpg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clemcop kabata.jpg

clemcopep kabata.jpg

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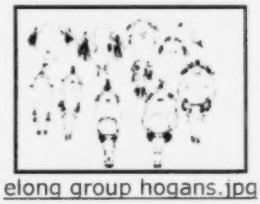
clempref kabata.jpg

clemprem kabata.jpg

elong cop mxp schram .jpg


elong group hogans.jpg

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elongch4 hogans.jpg

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elongf piasecki .jpg

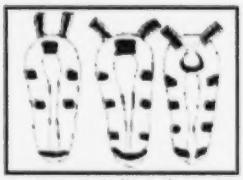
elongnaup1 hogans.jpg

elongnaup2 hogans.jpg

elongpref piasecki .jpg

elongprem piasecki .jpg

elongprem1 hogans.jpg


pectnauplii schram .jpg

poll naup and cop schram .jpg

salch1 johnson albright.jpg

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salch1.jpg

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salch3 johnson albright.jpg

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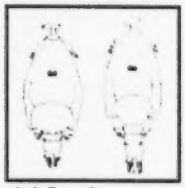
salch3 p1.jpg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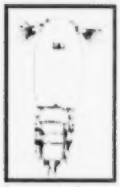
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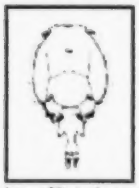
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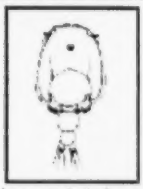
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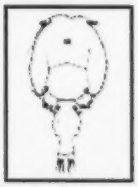
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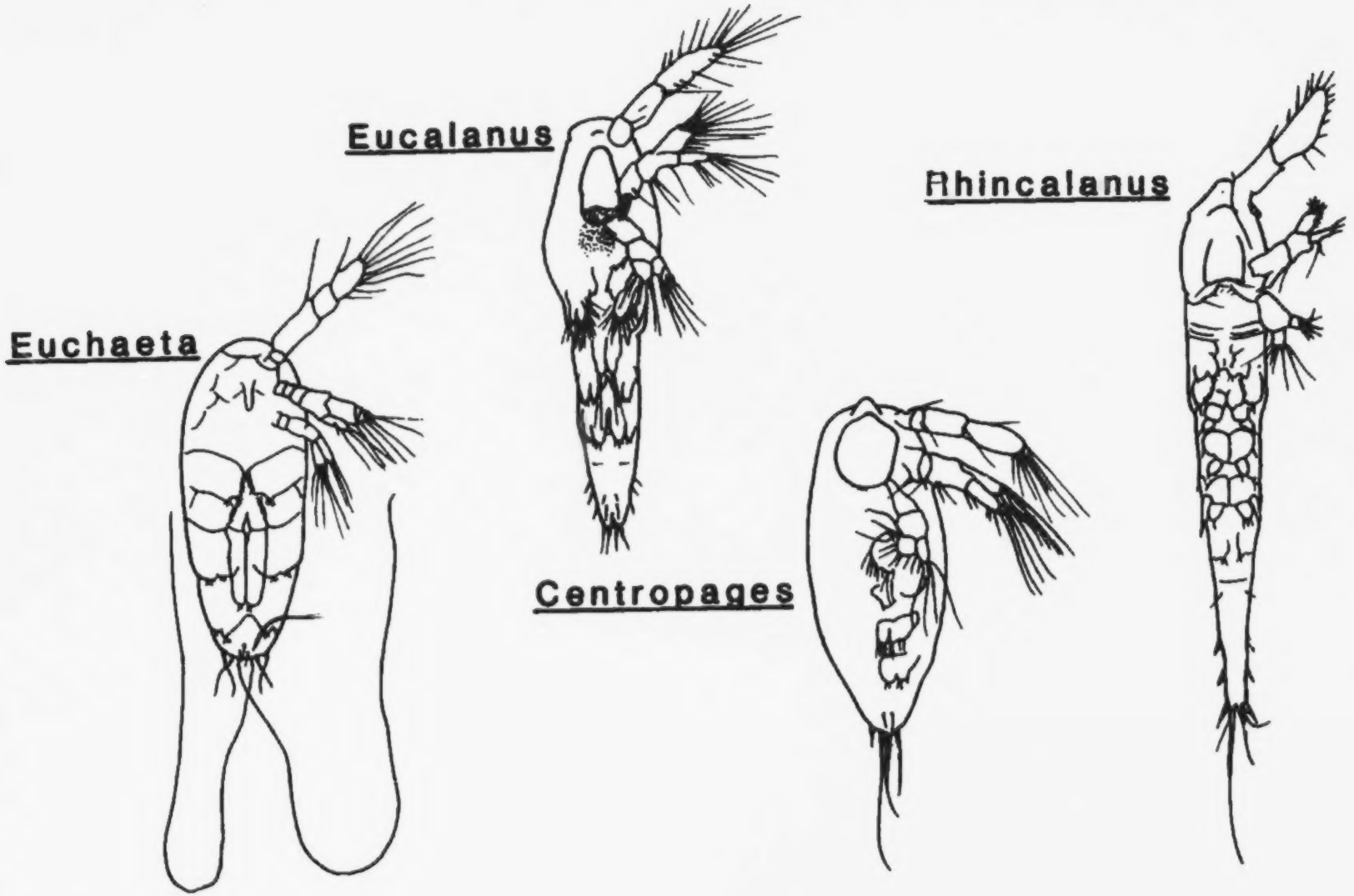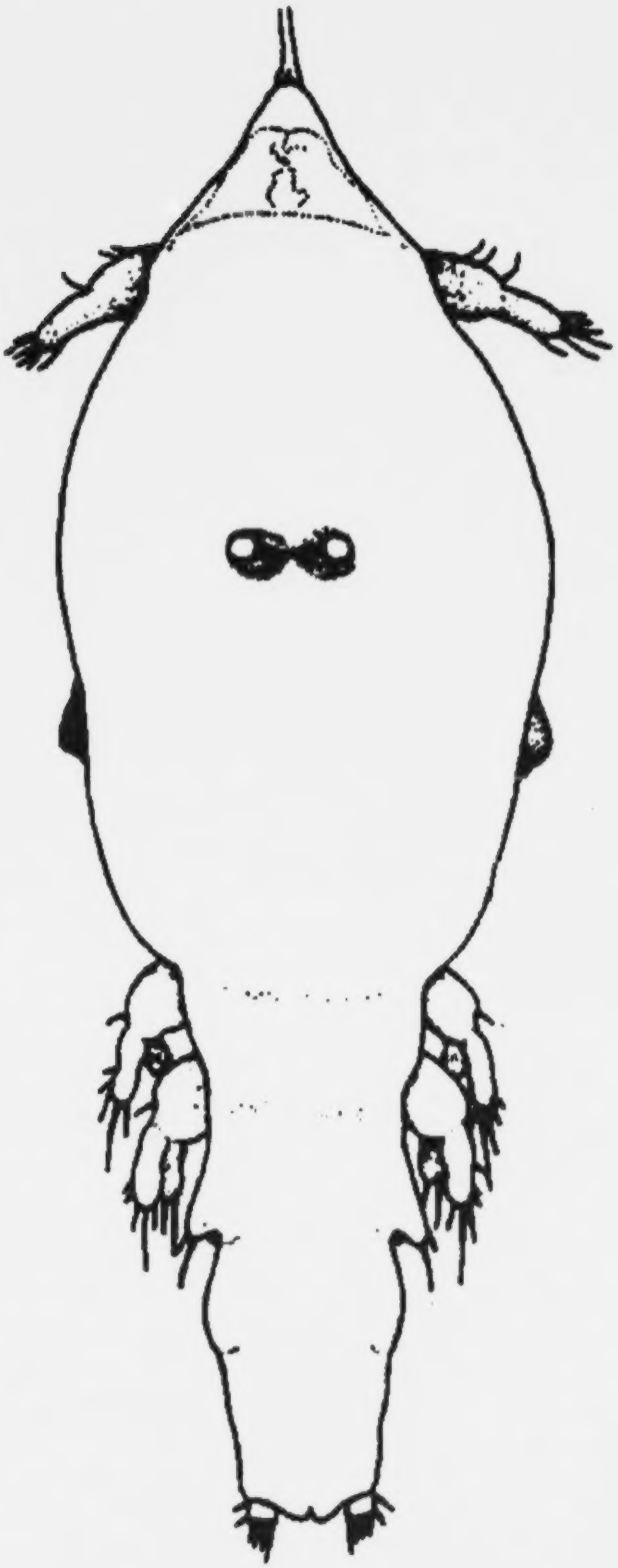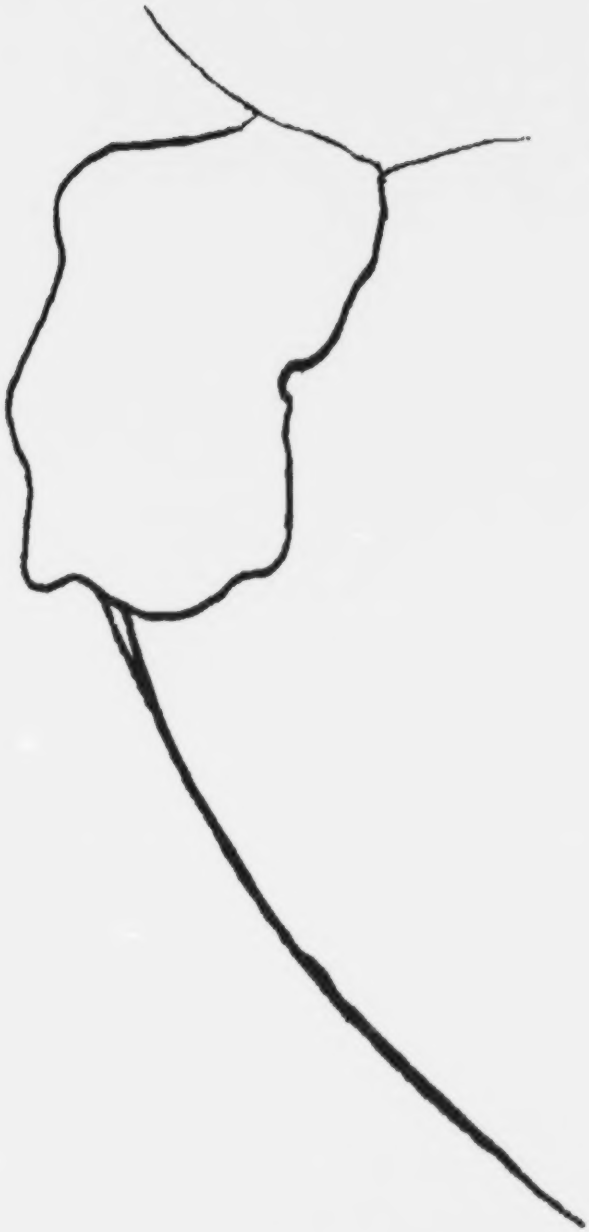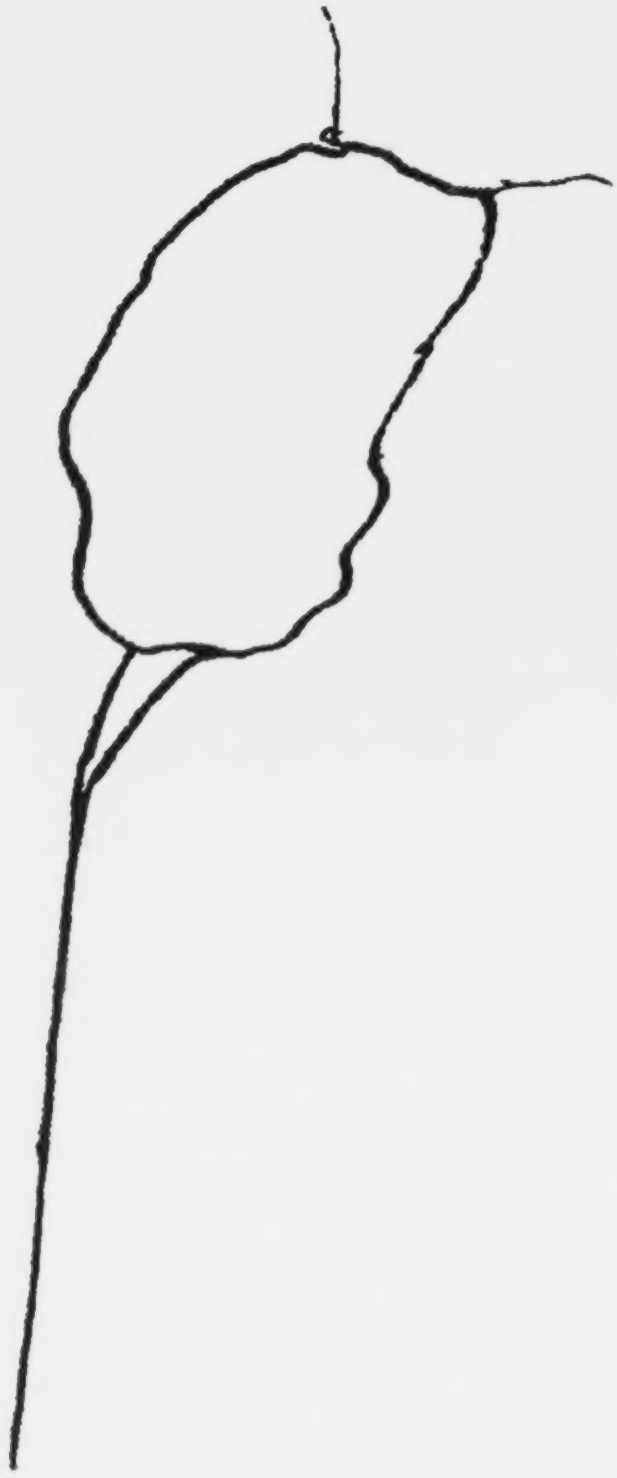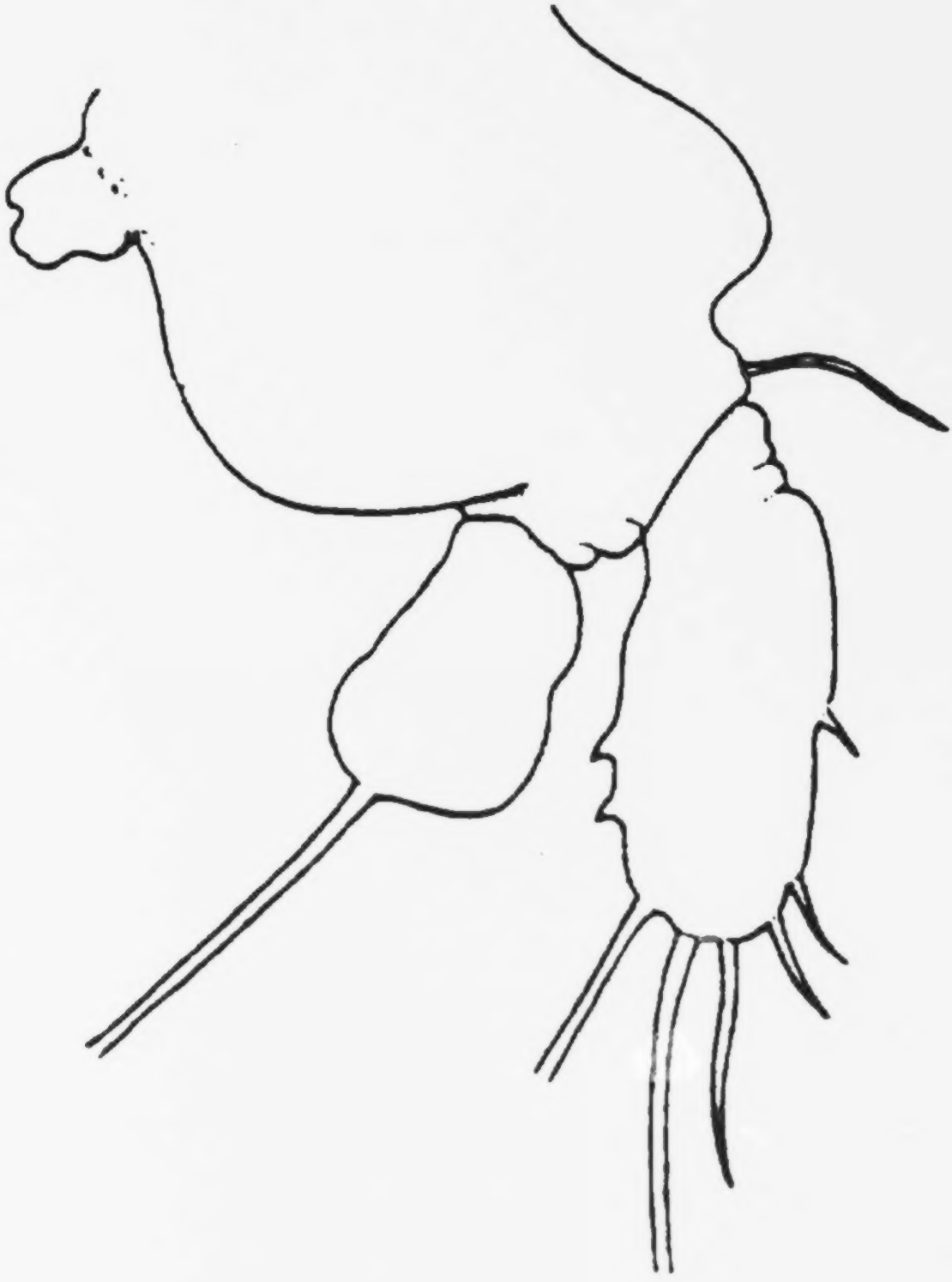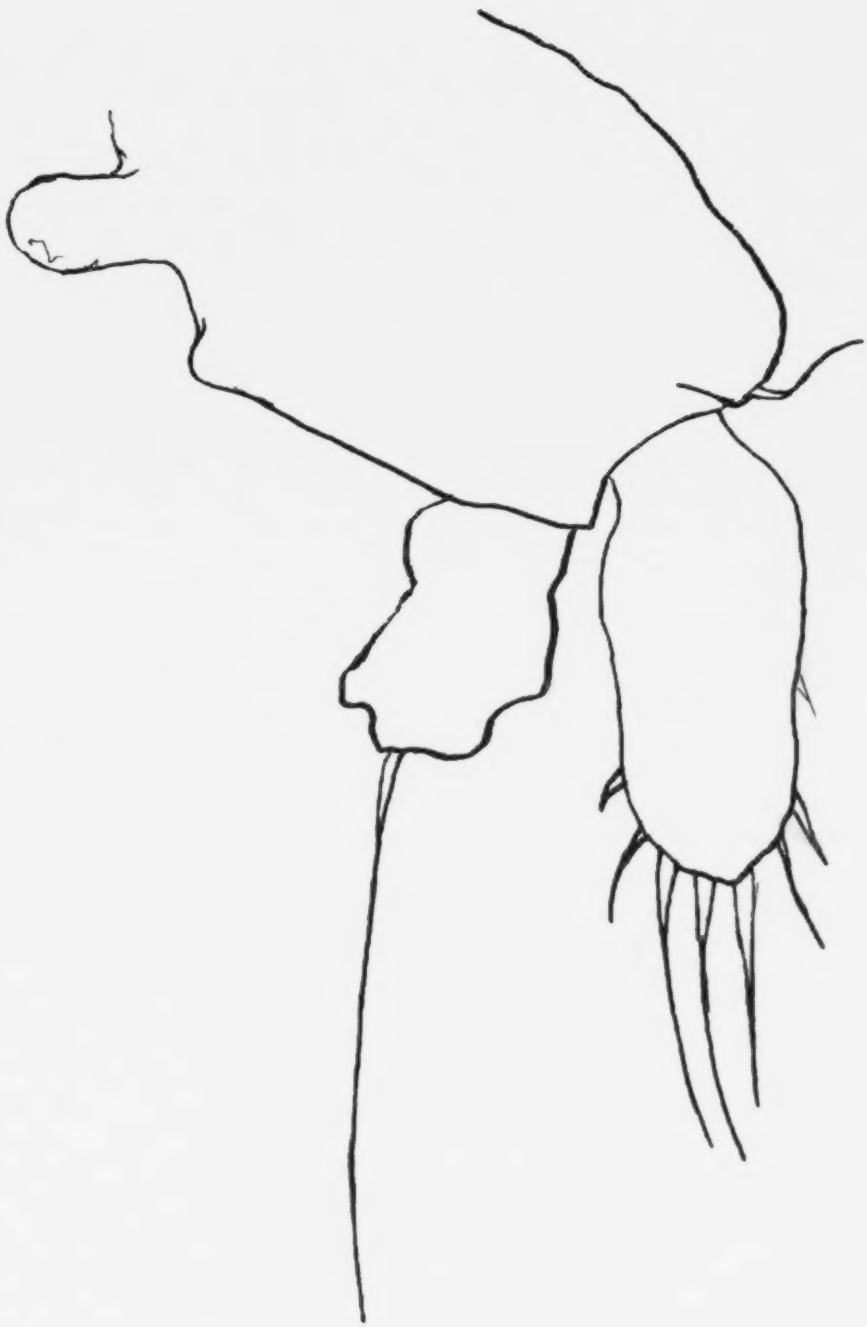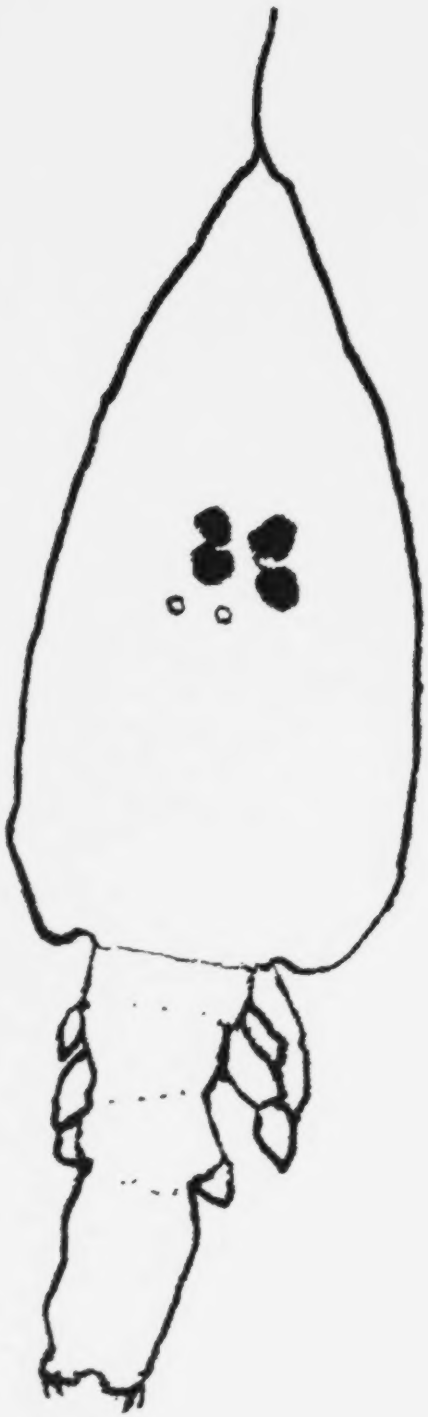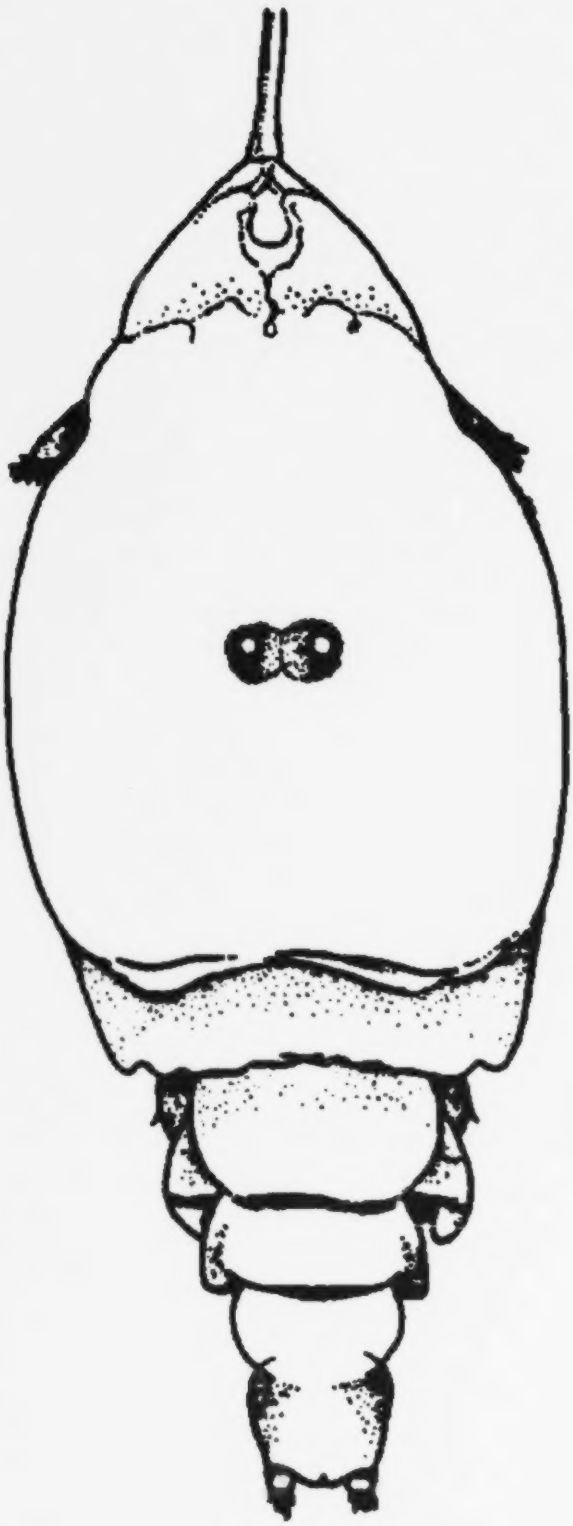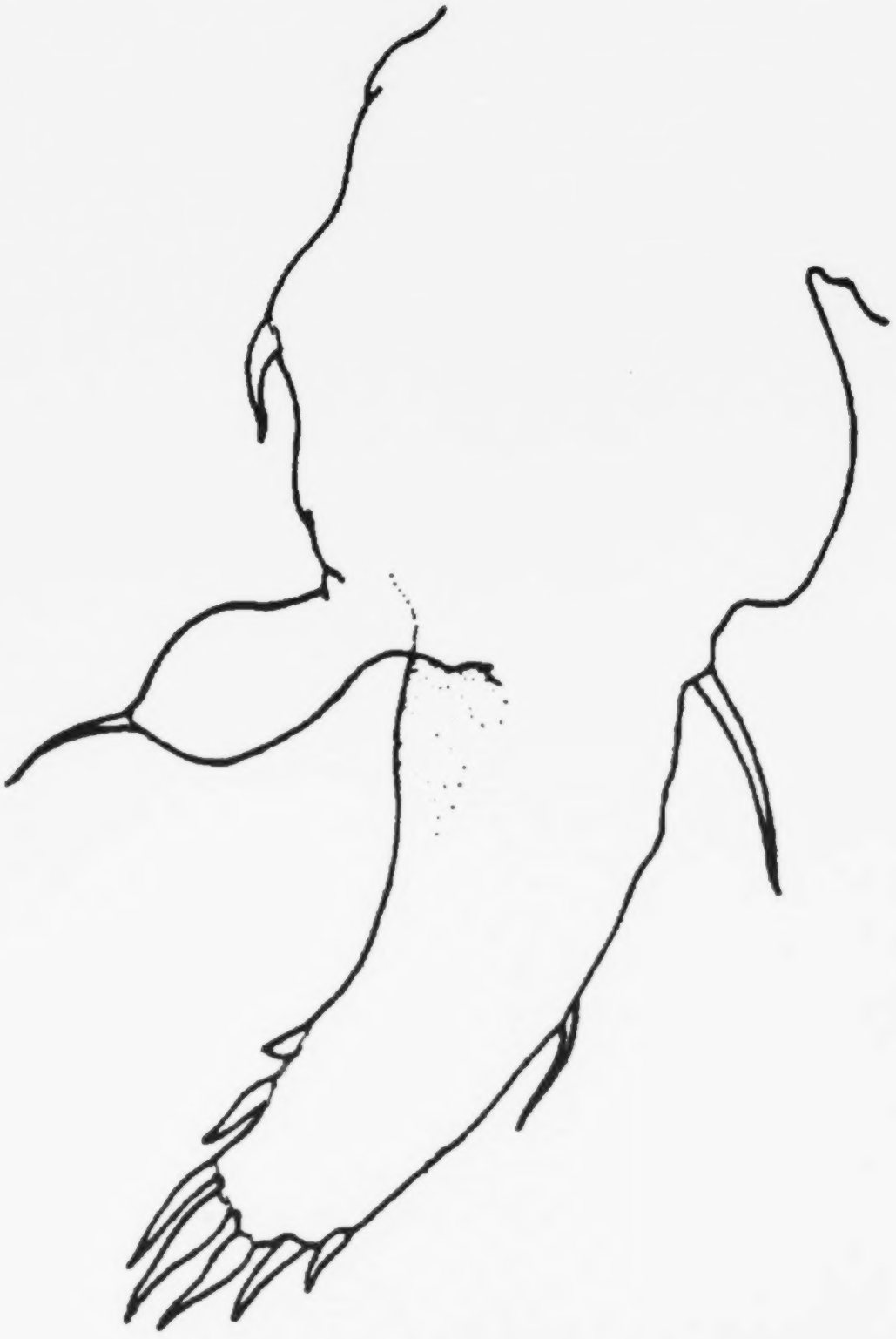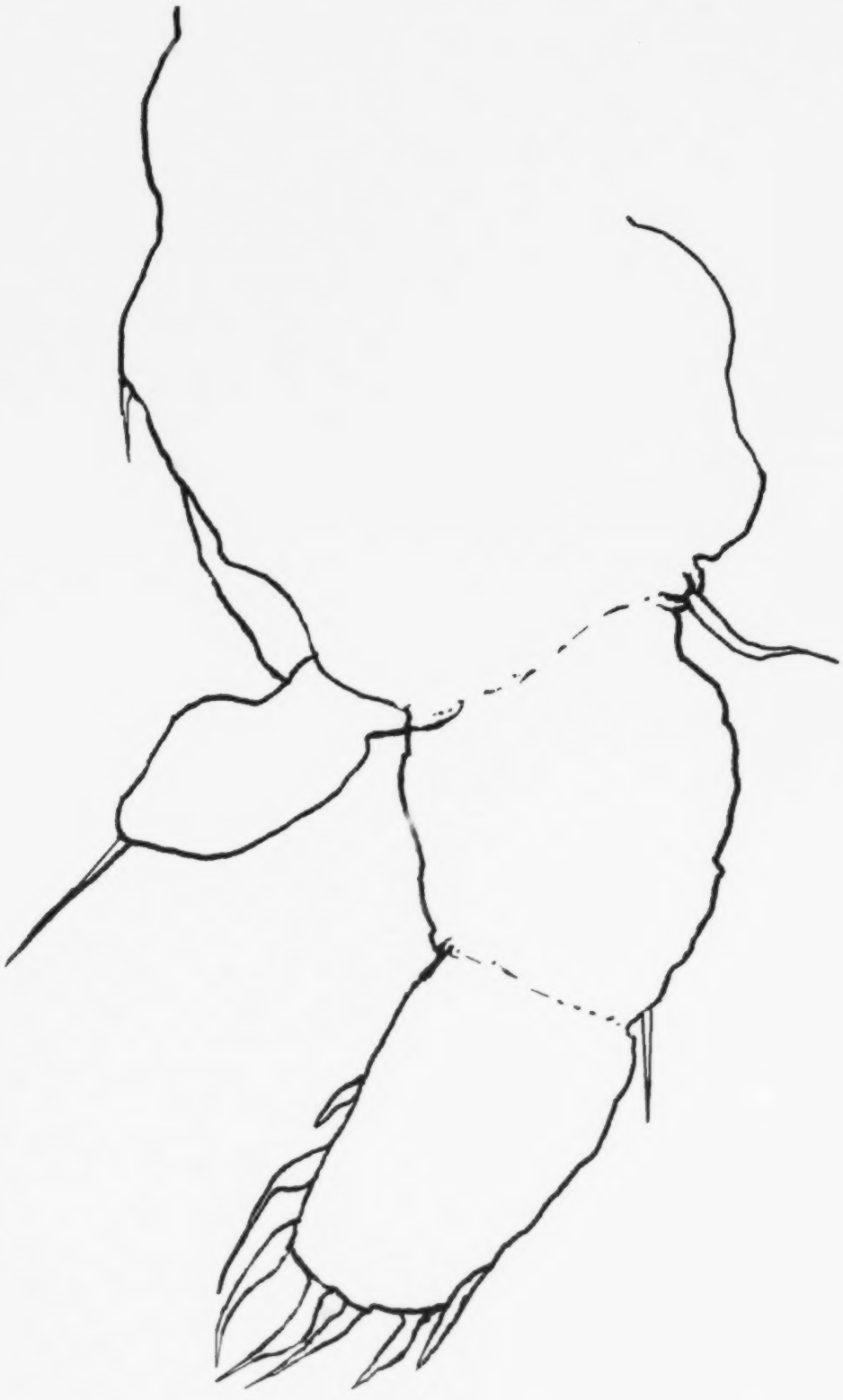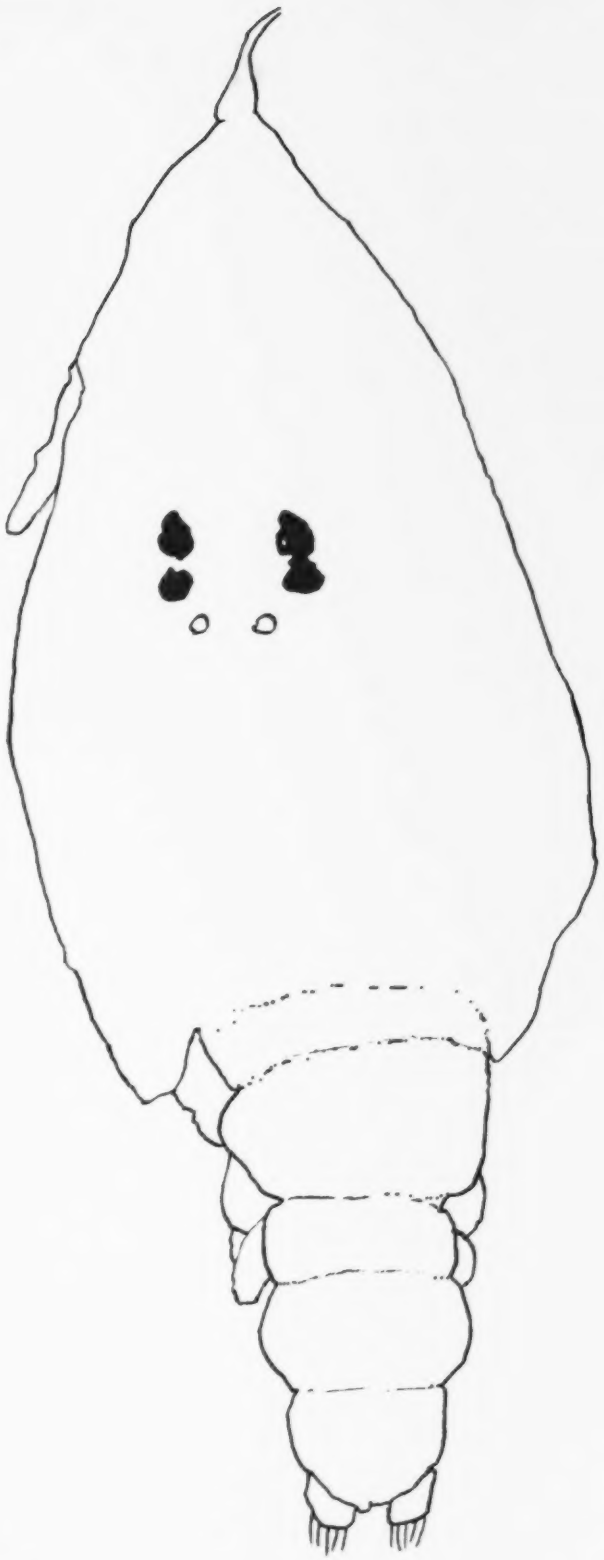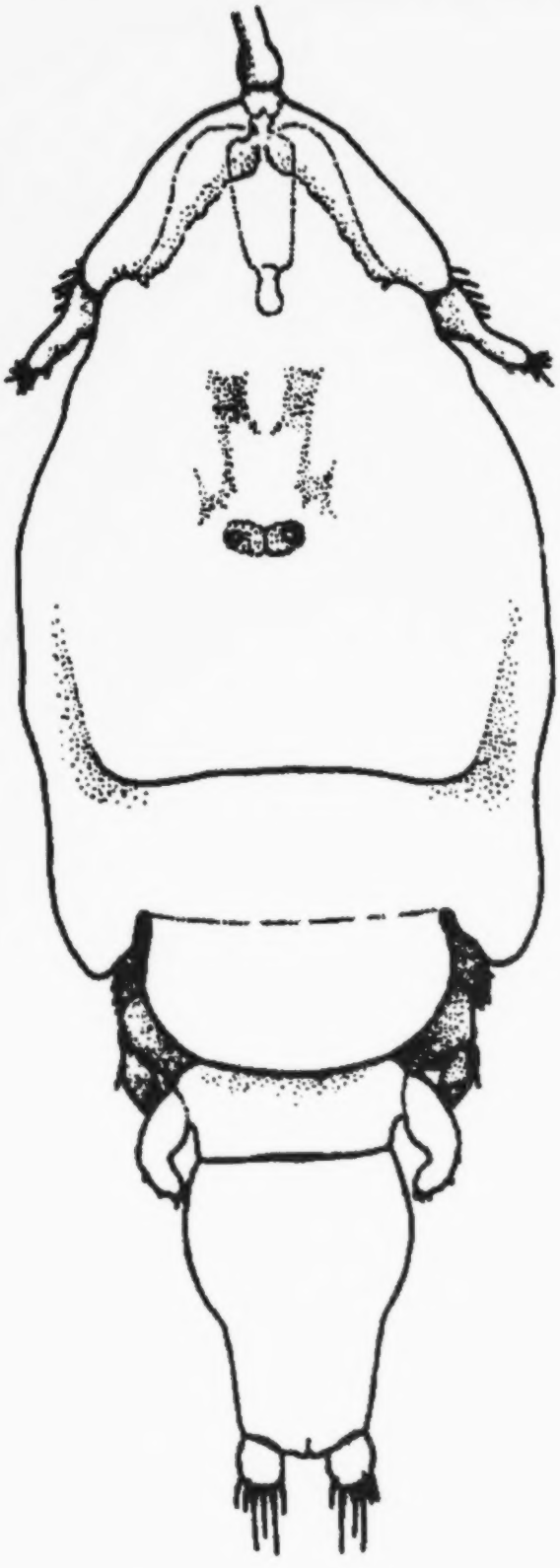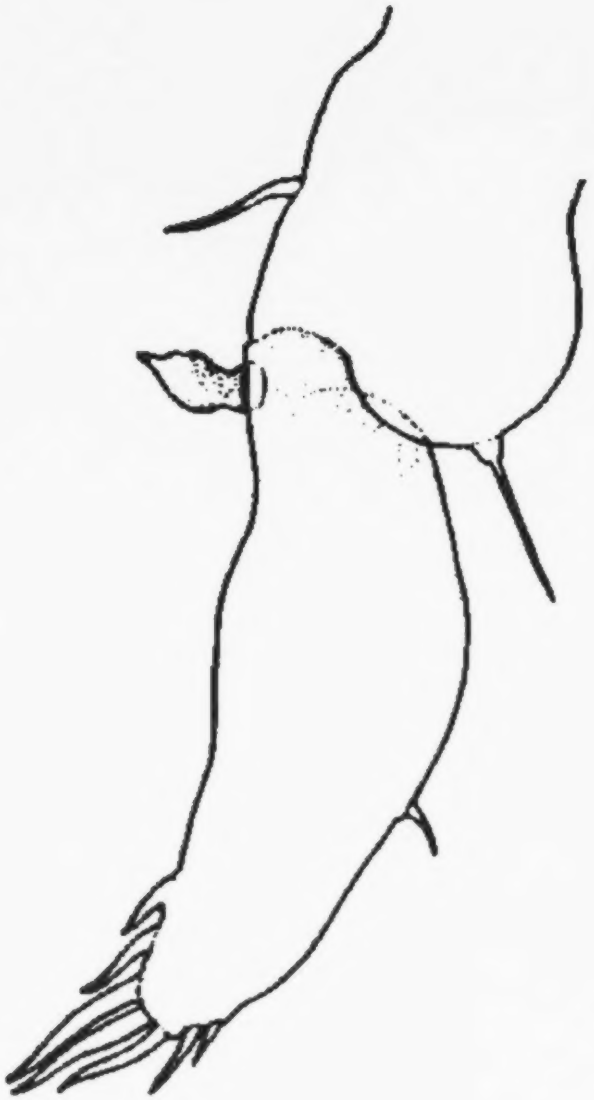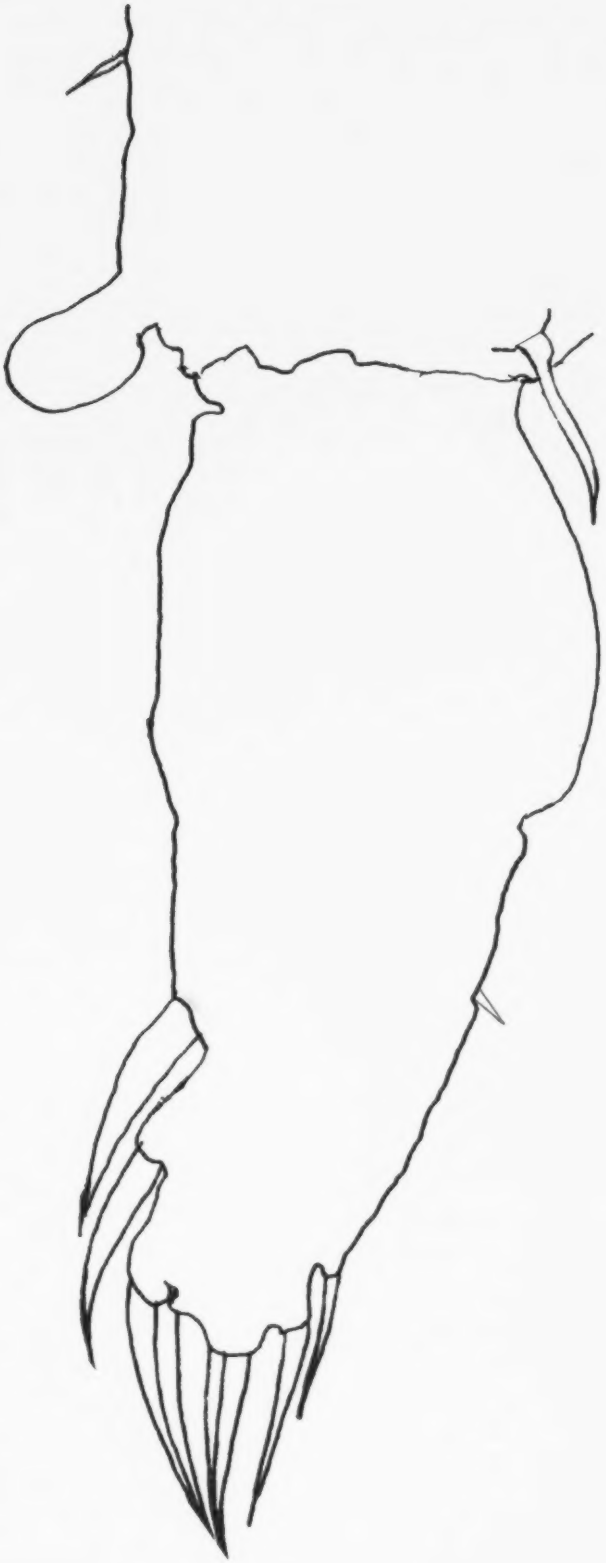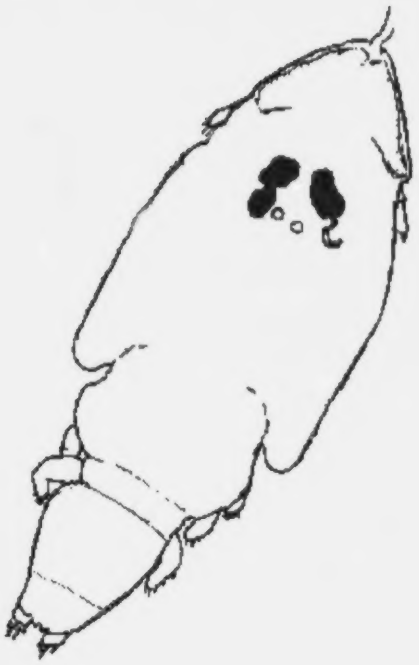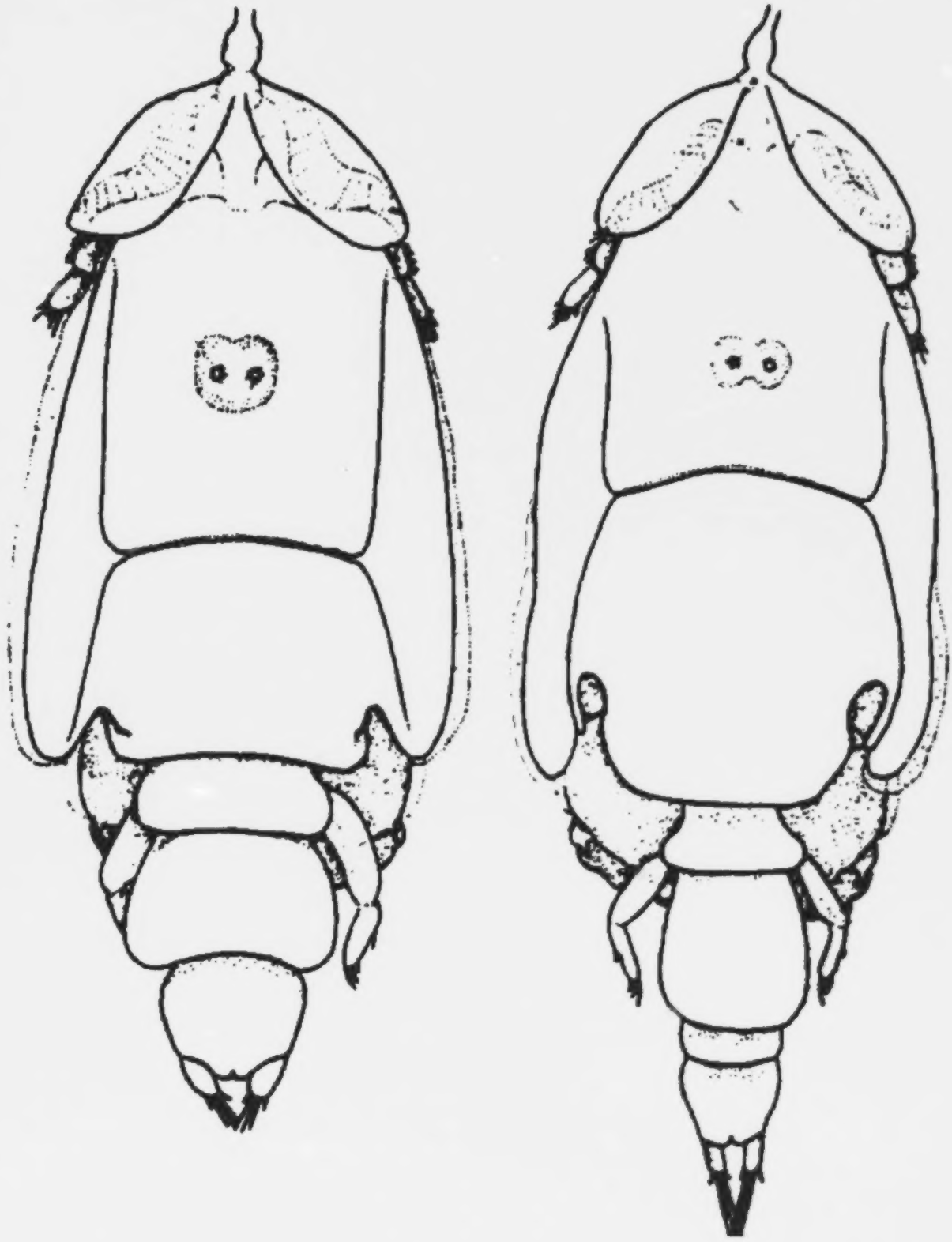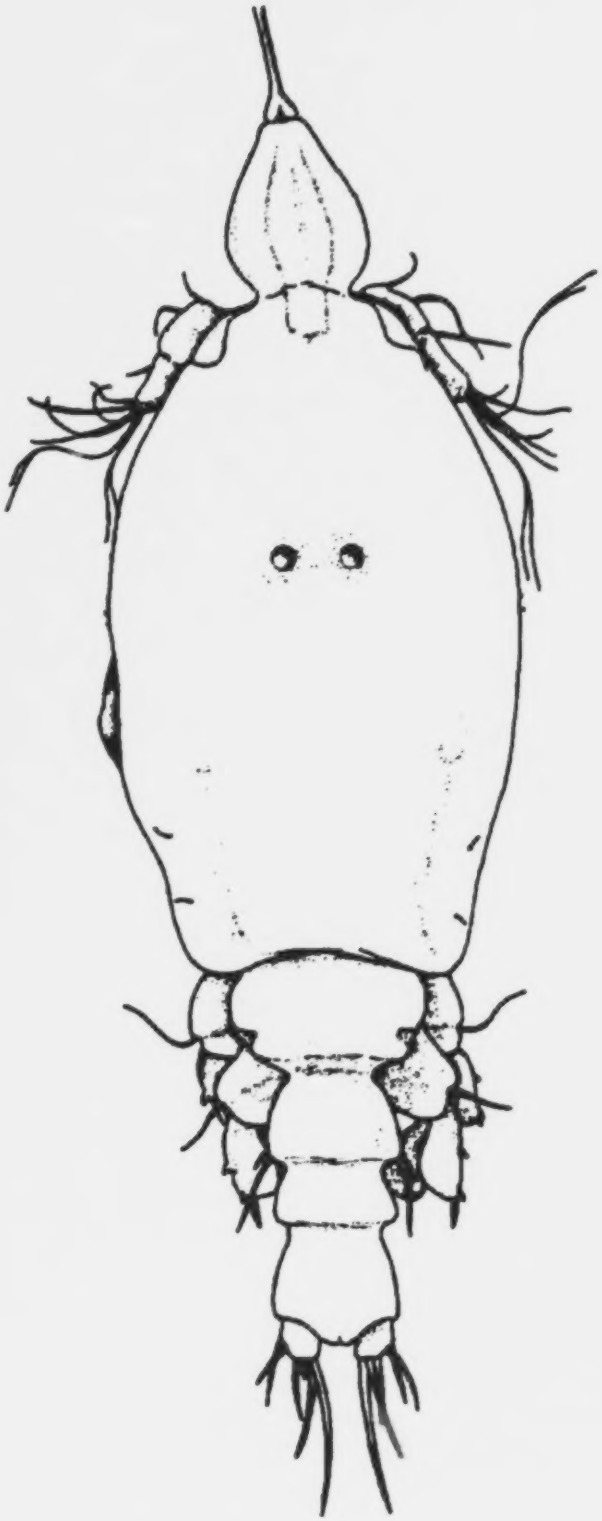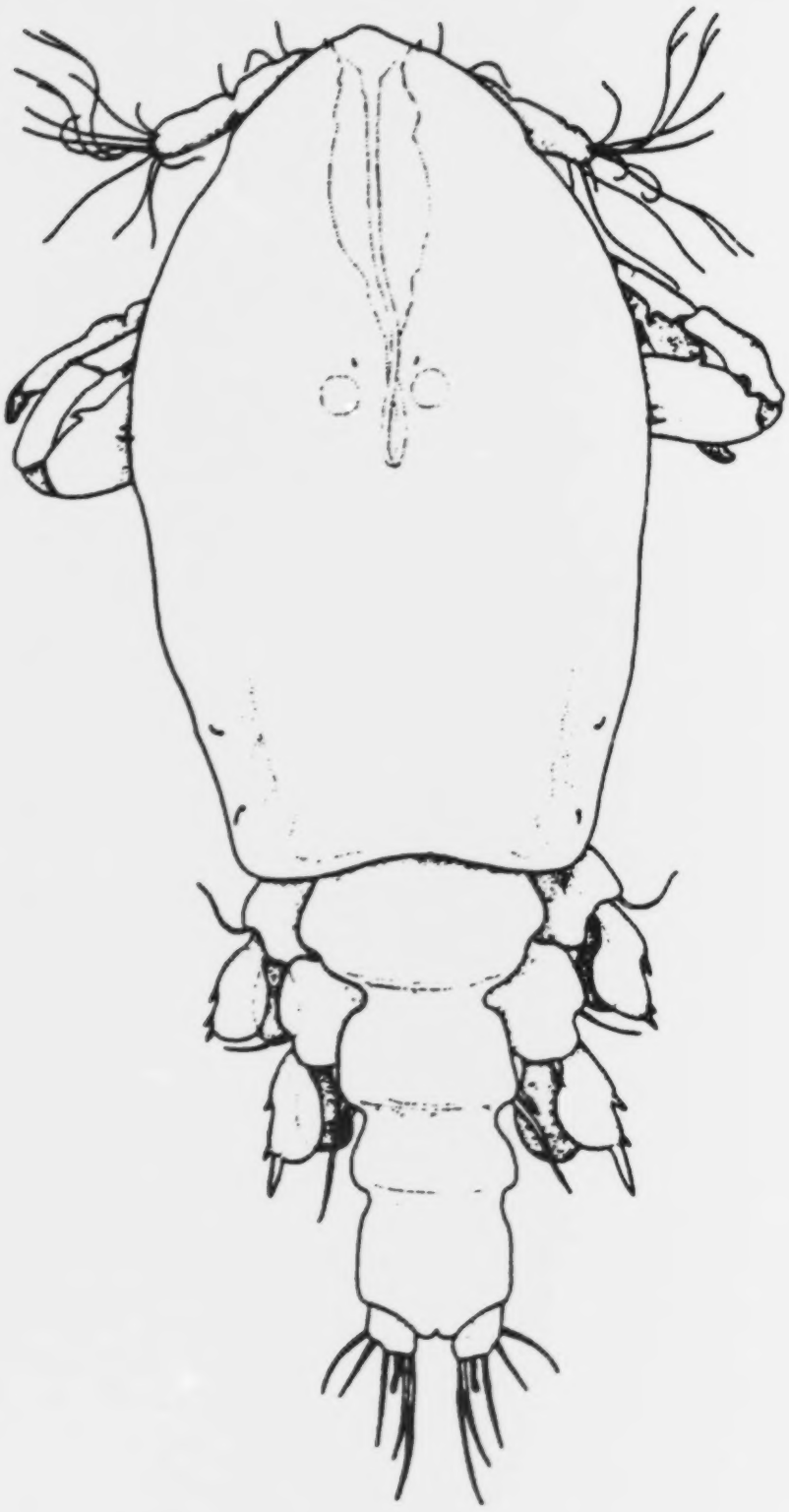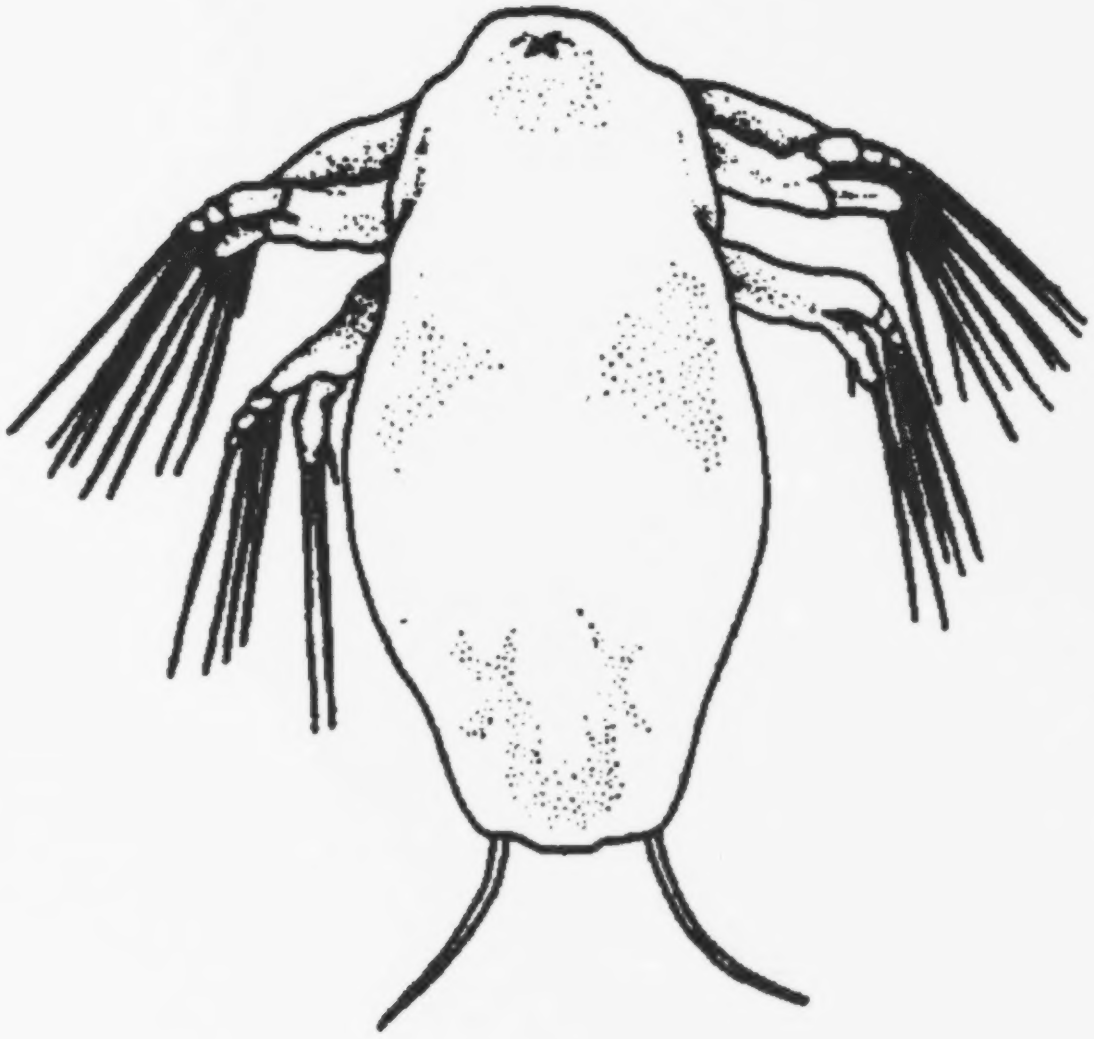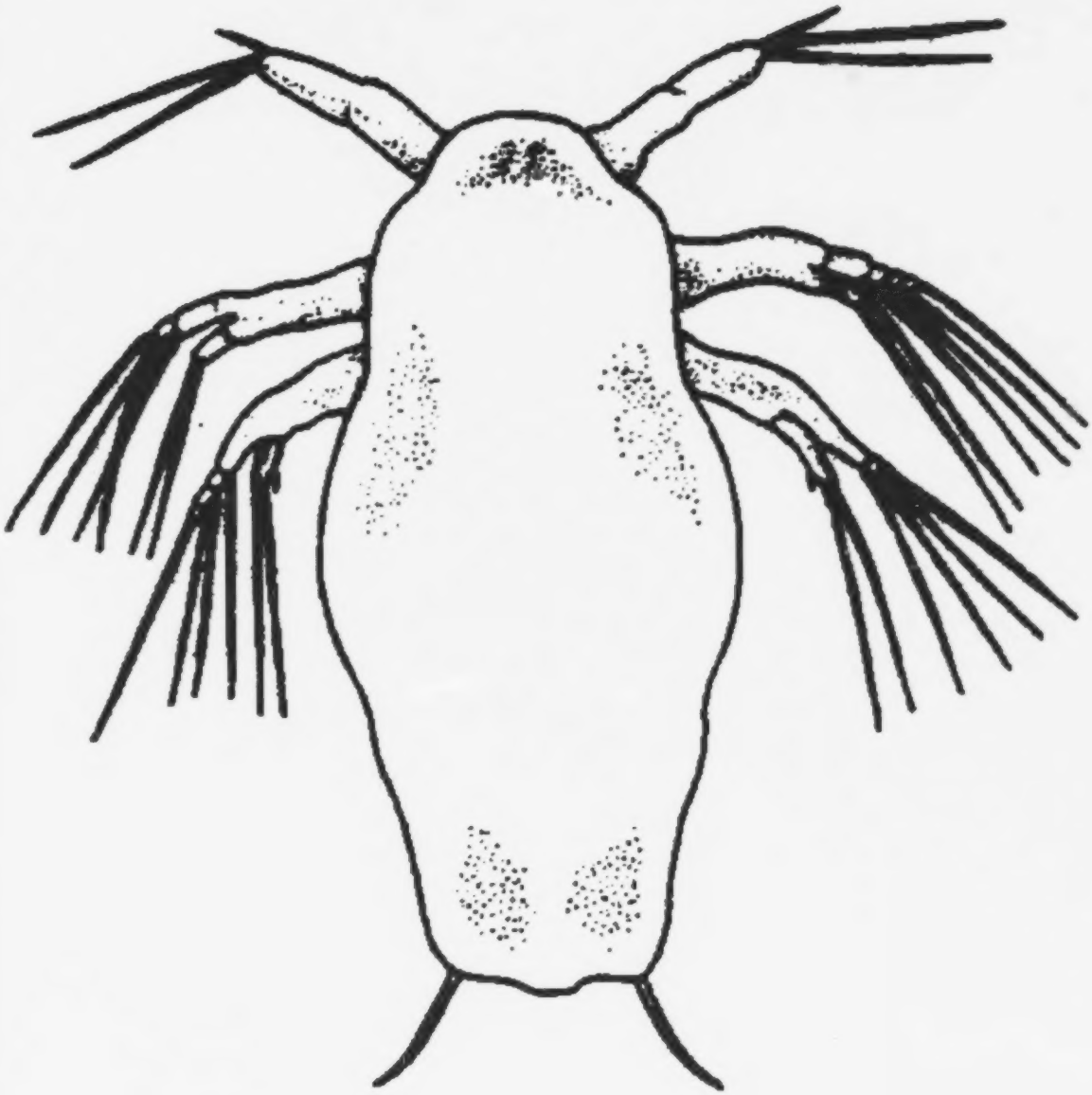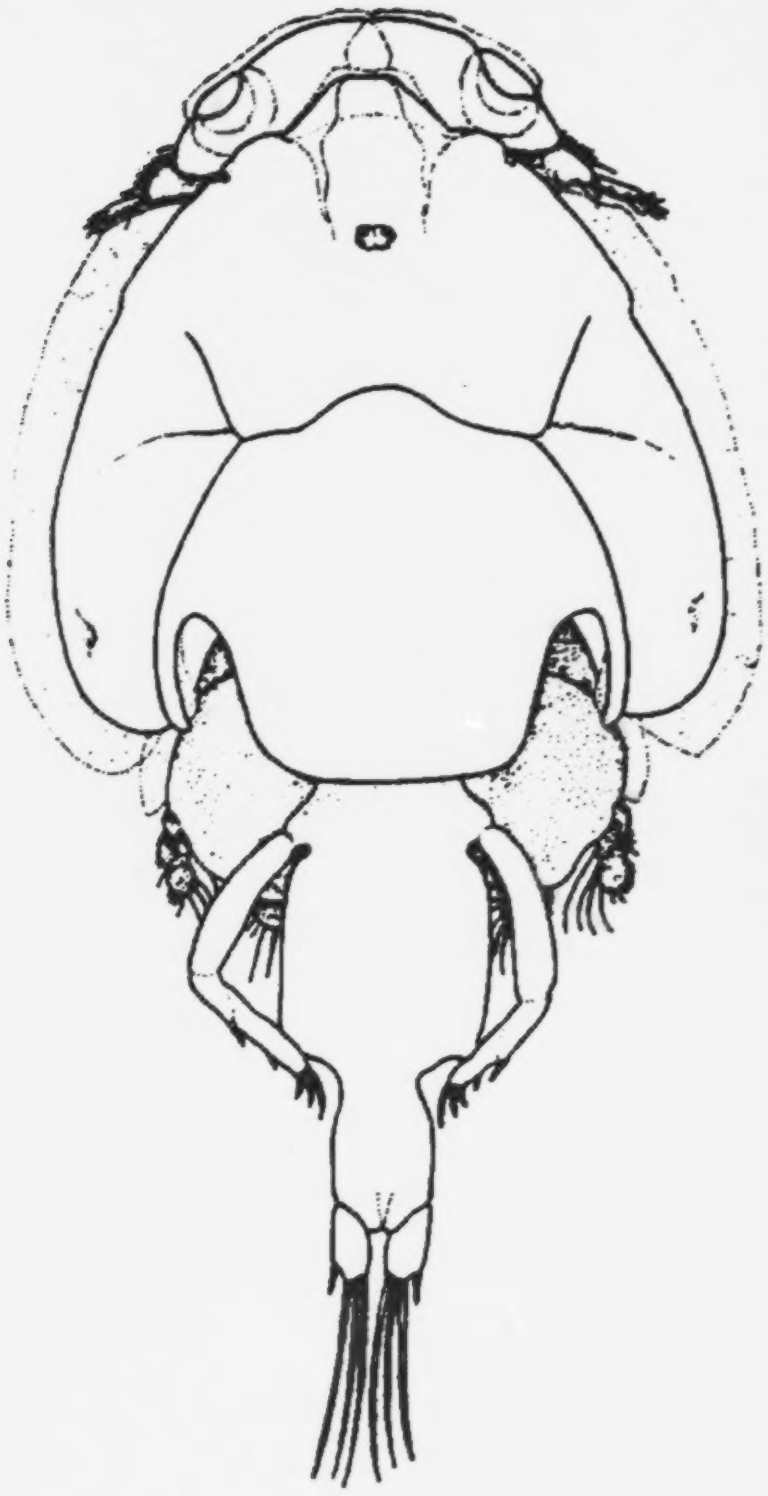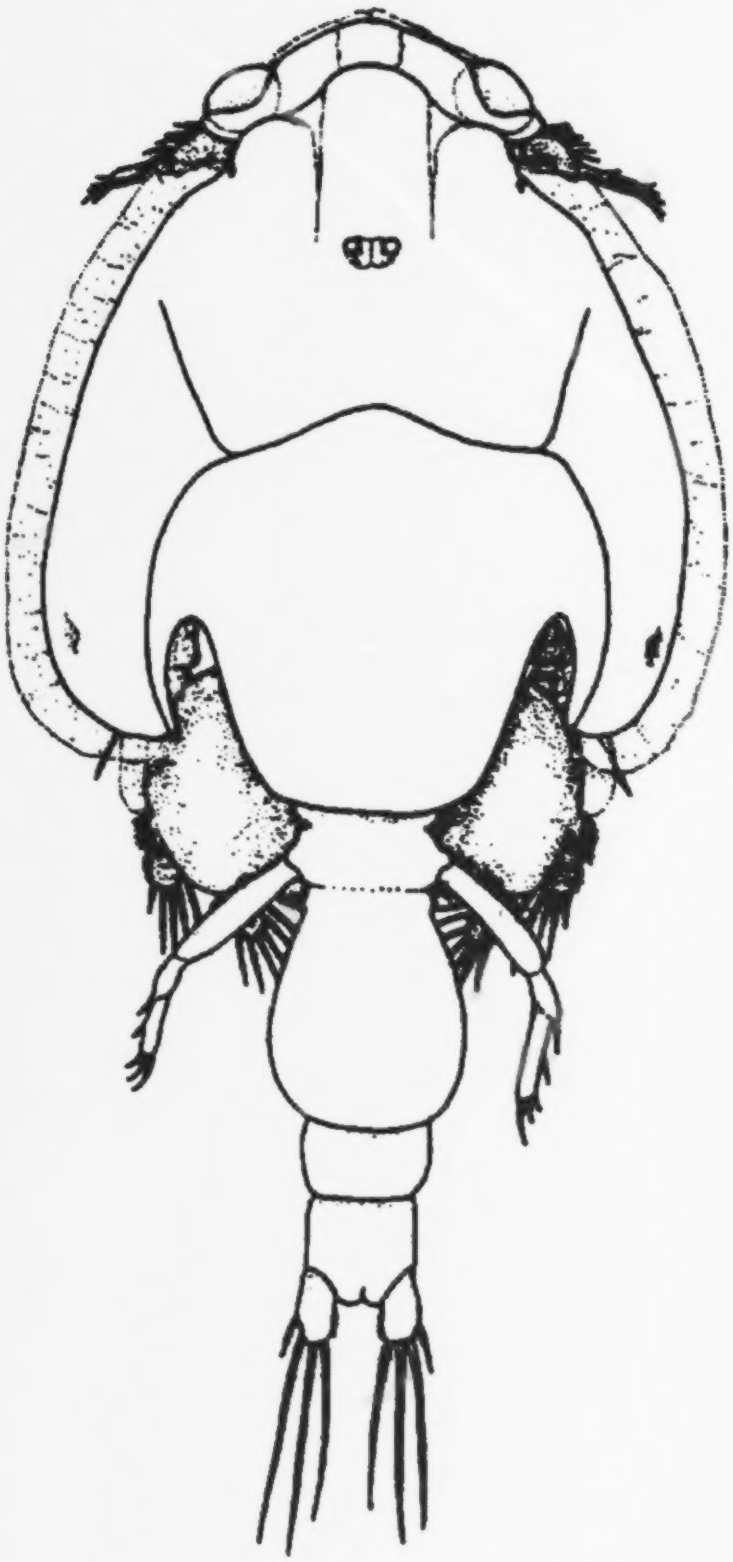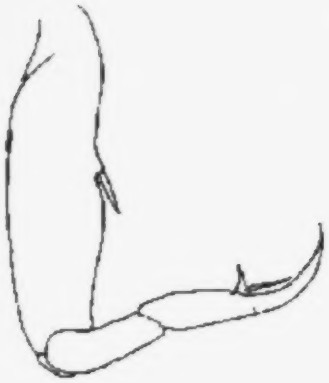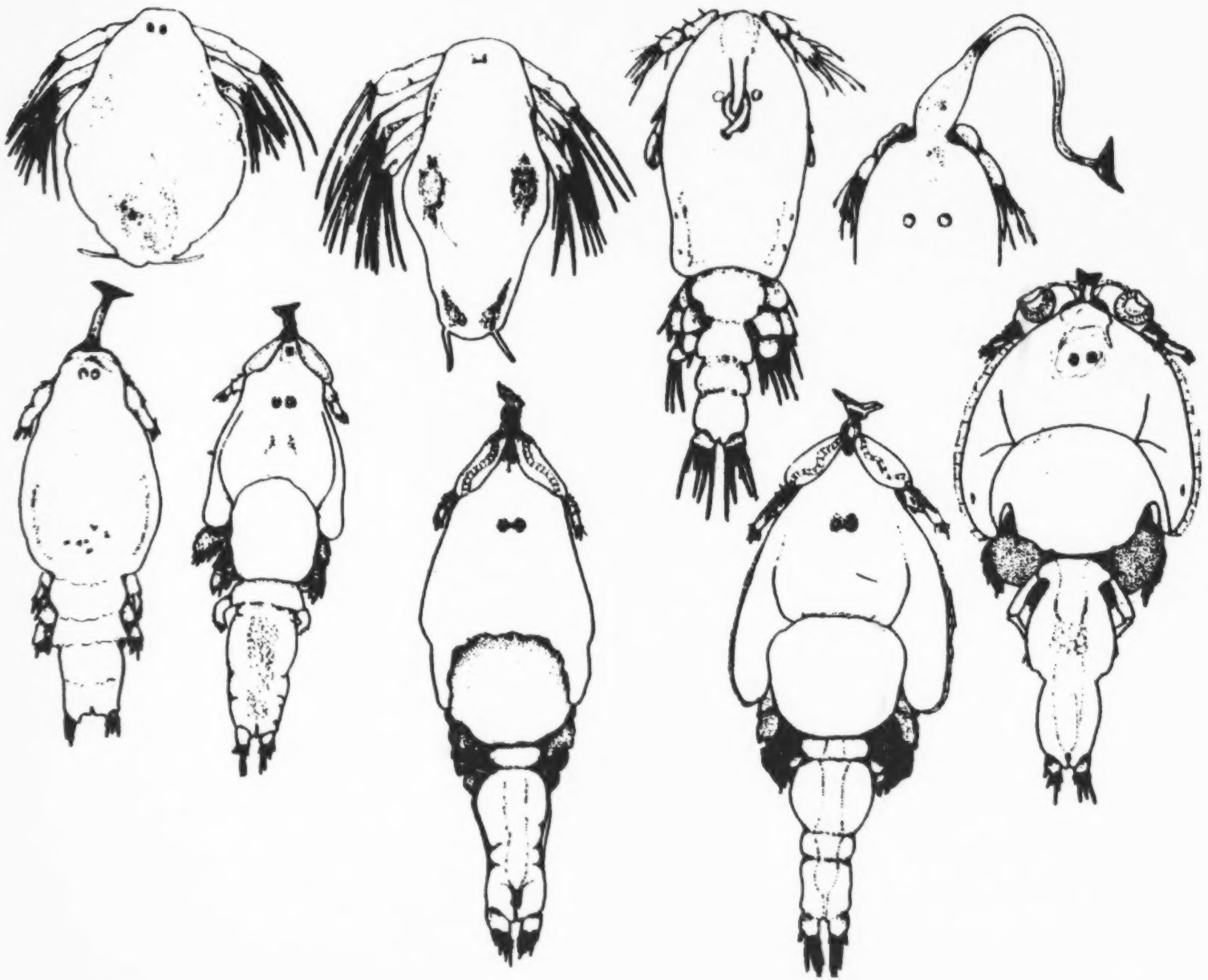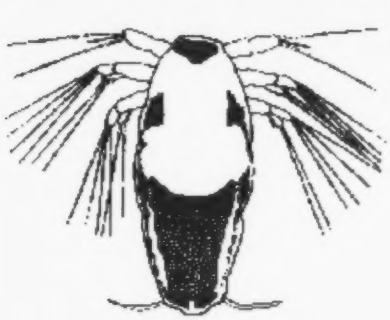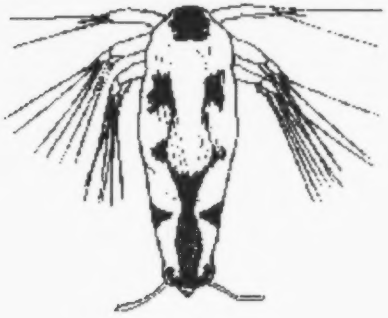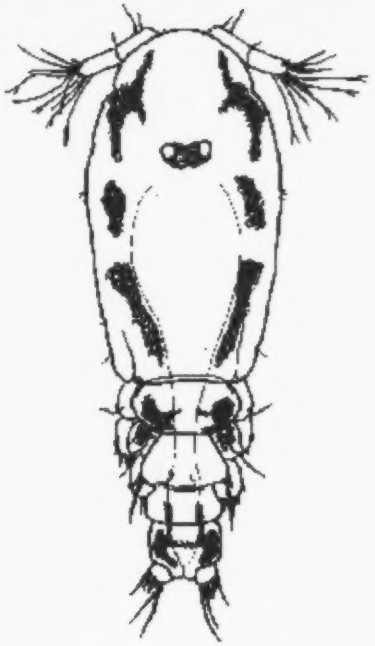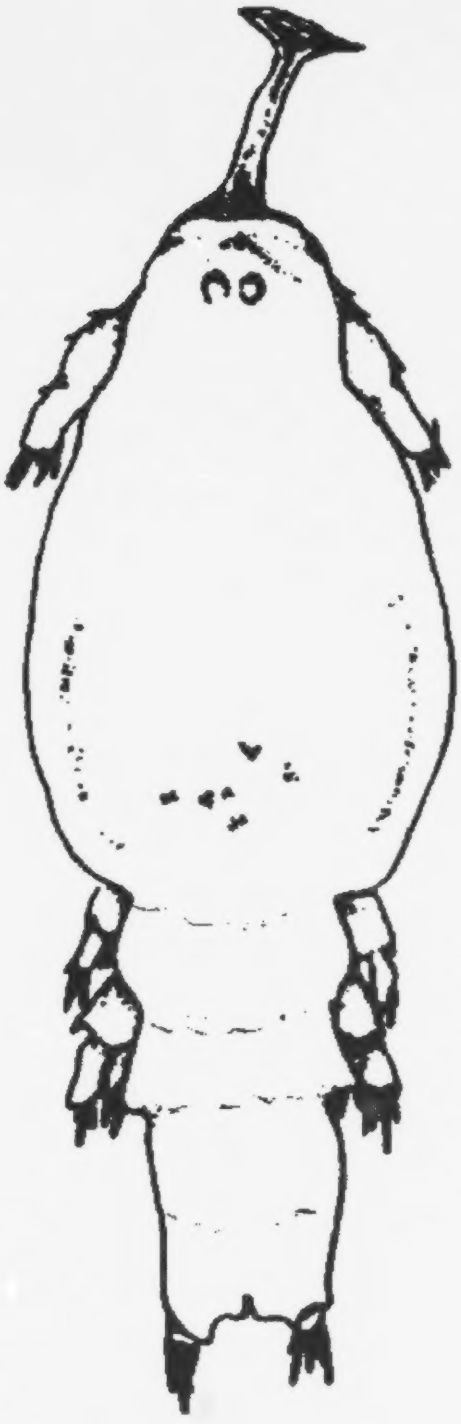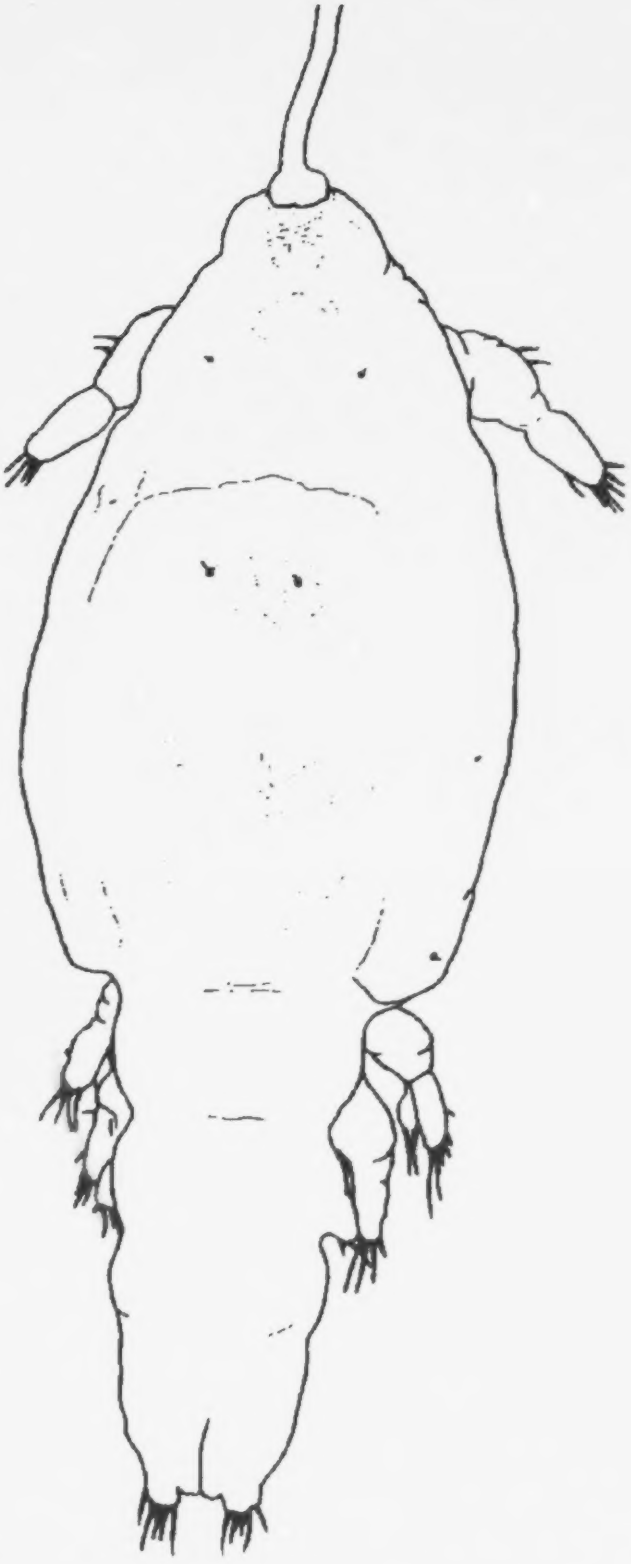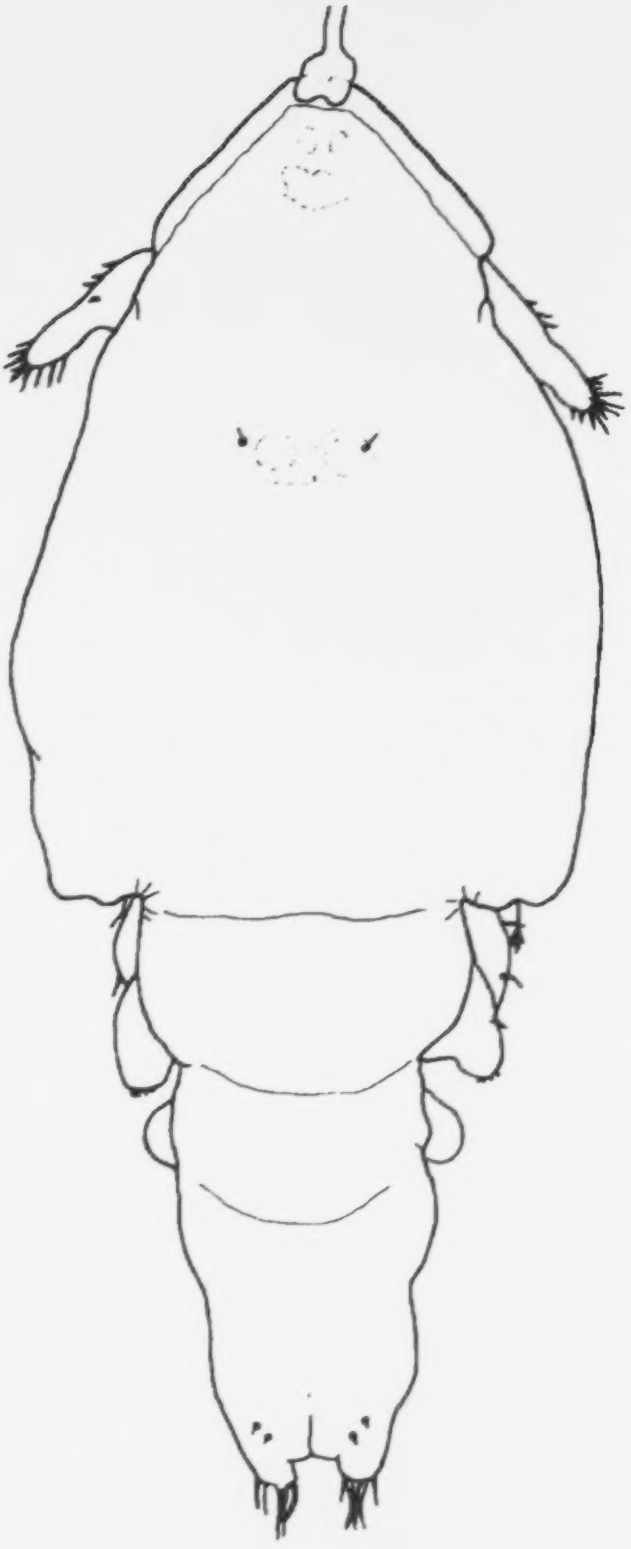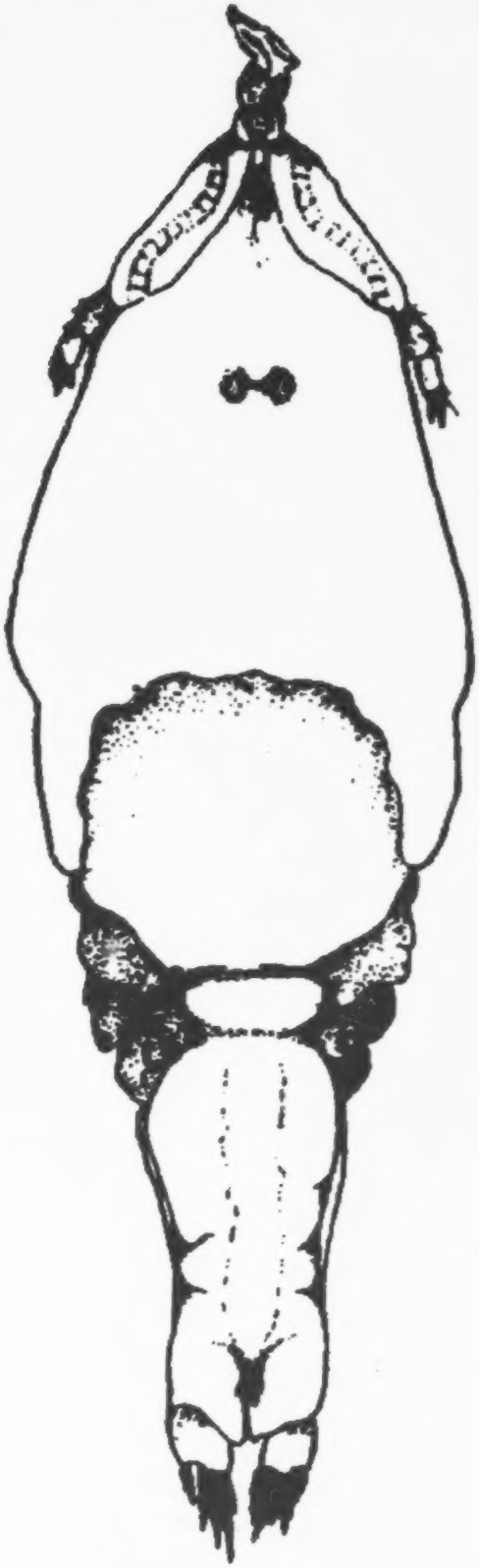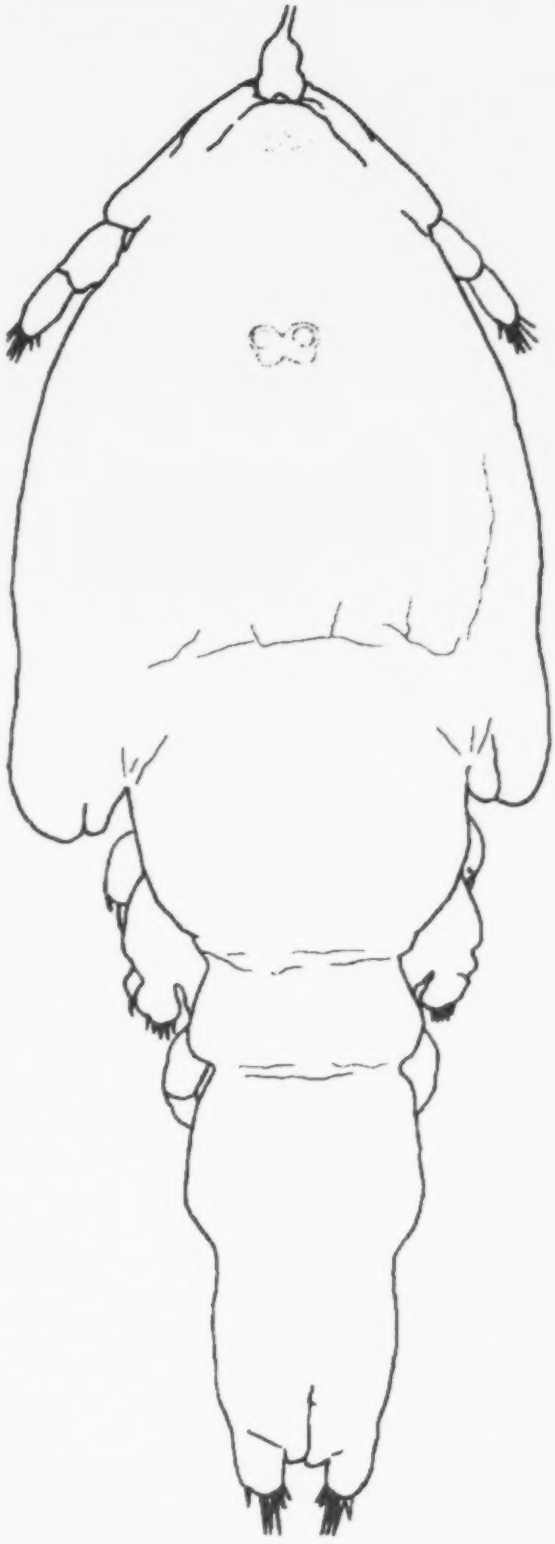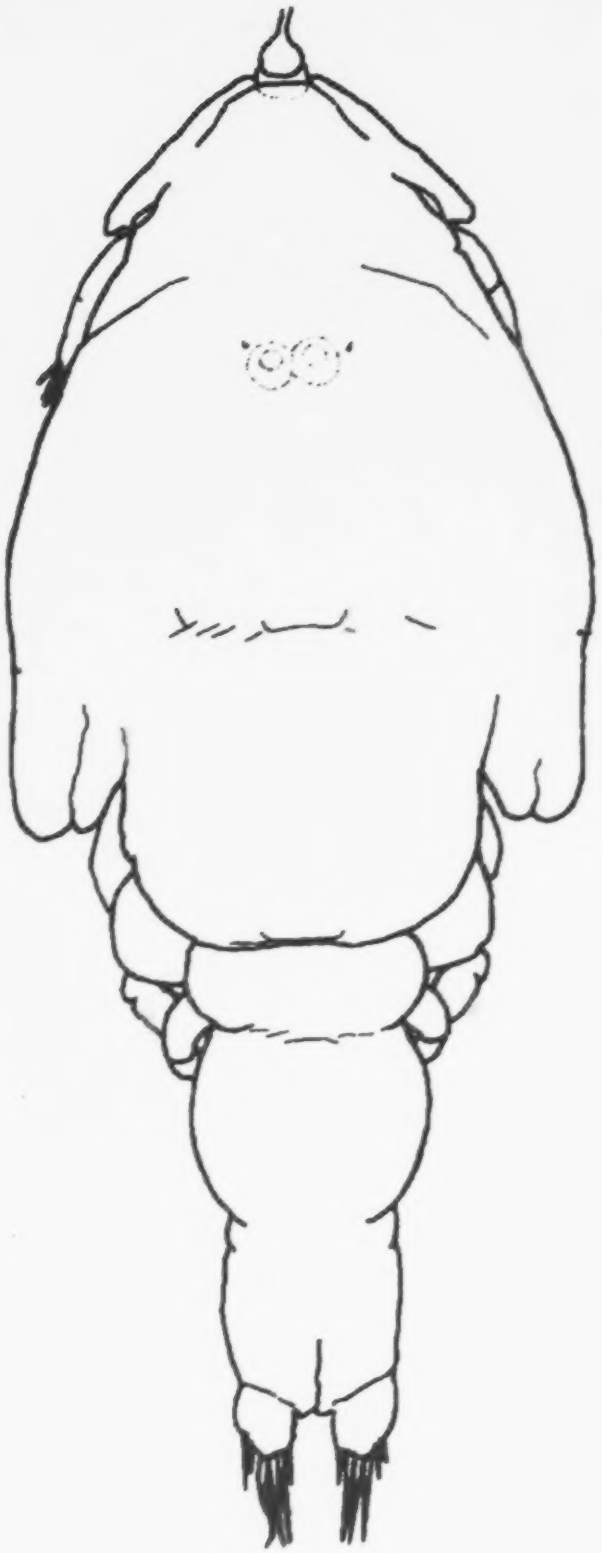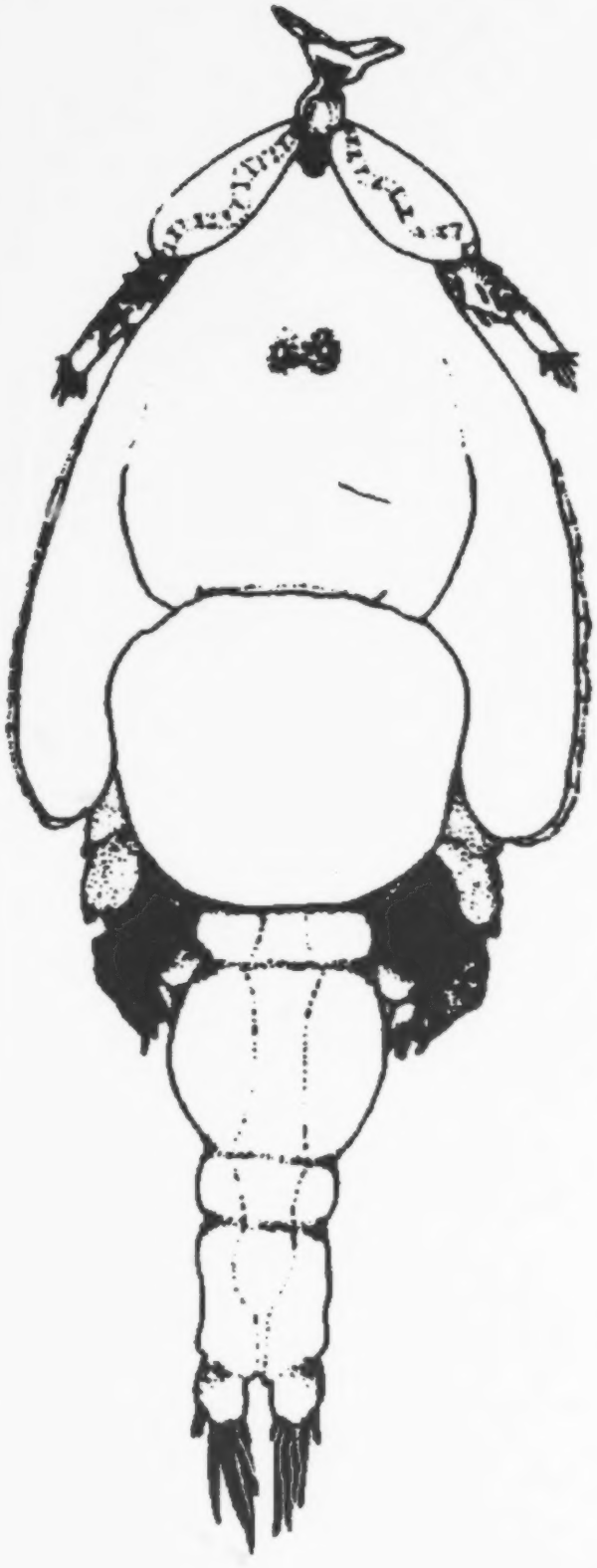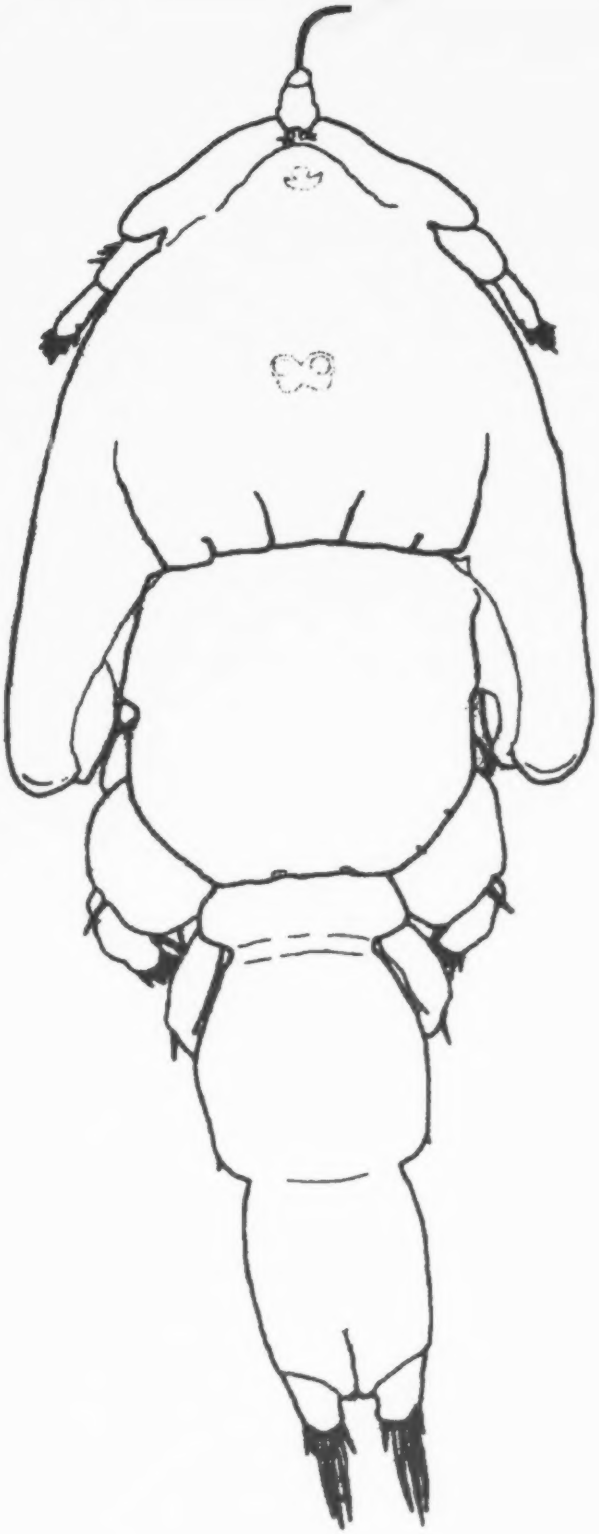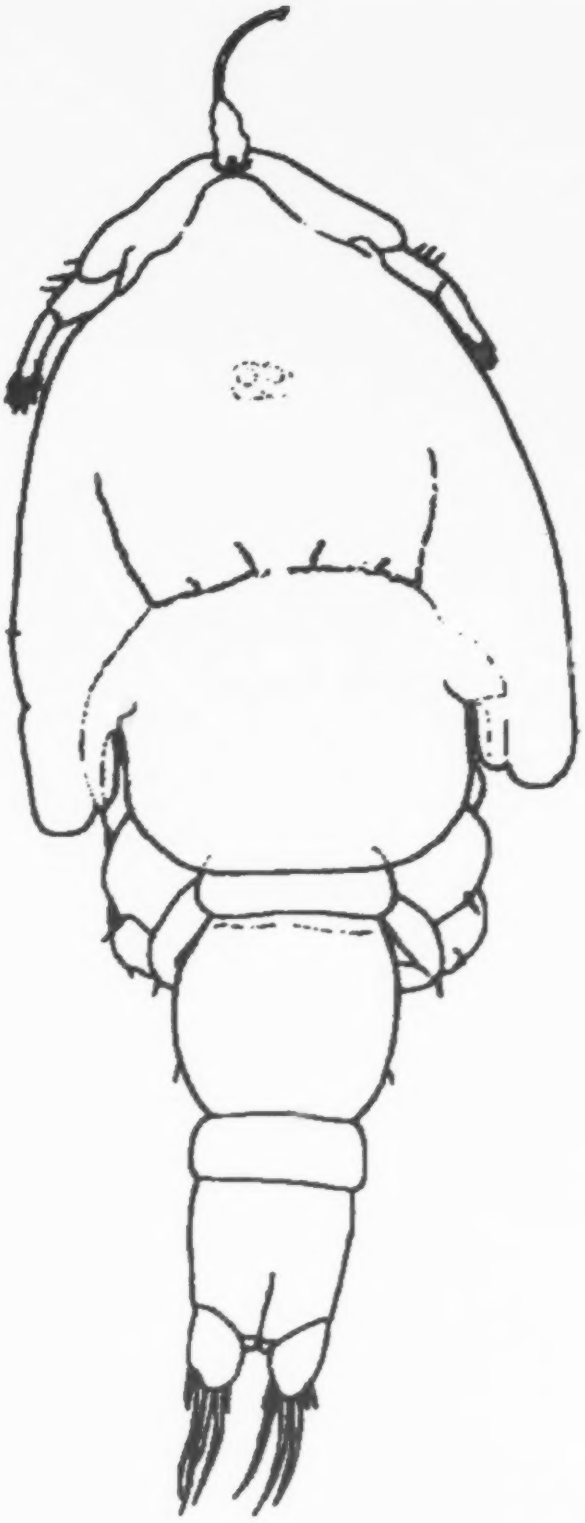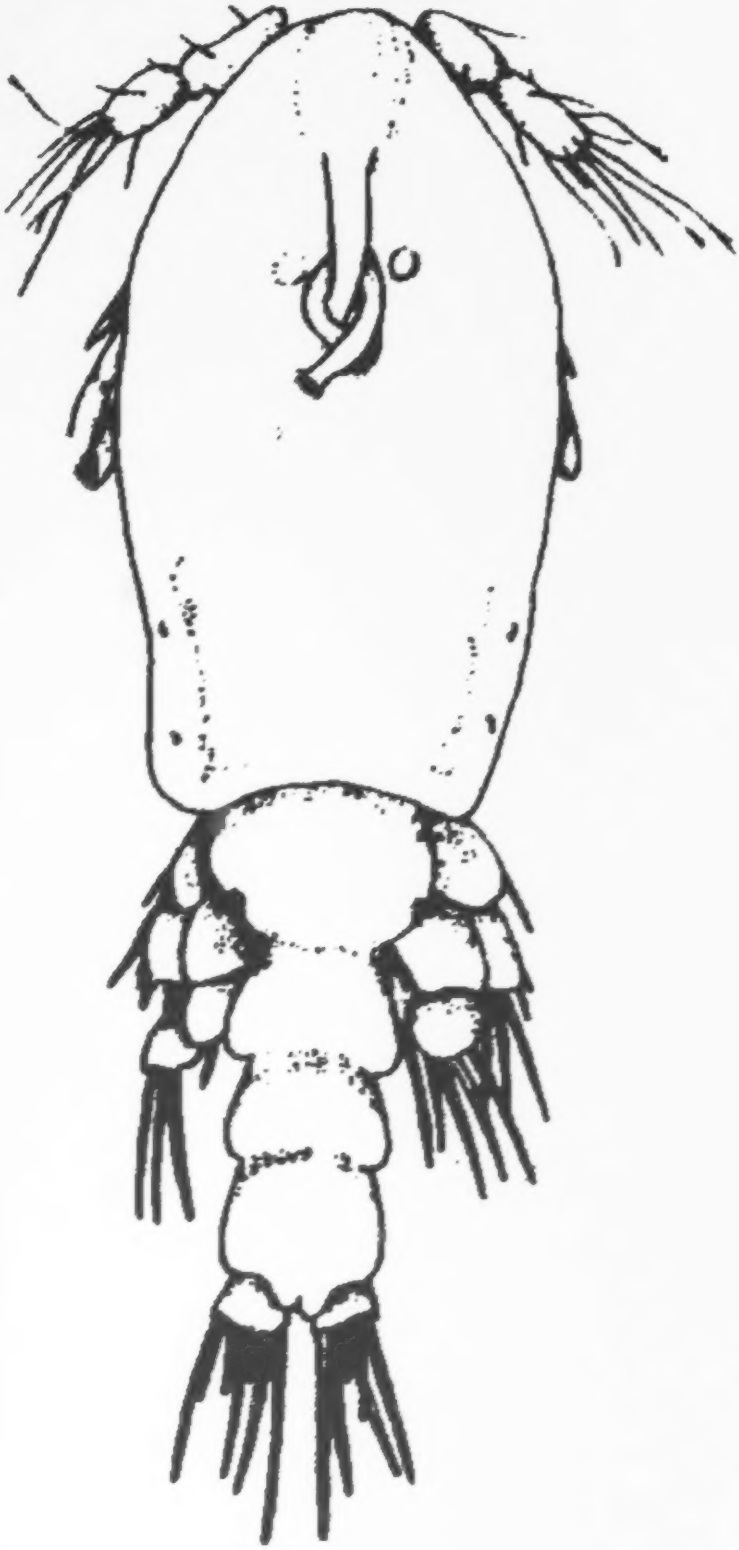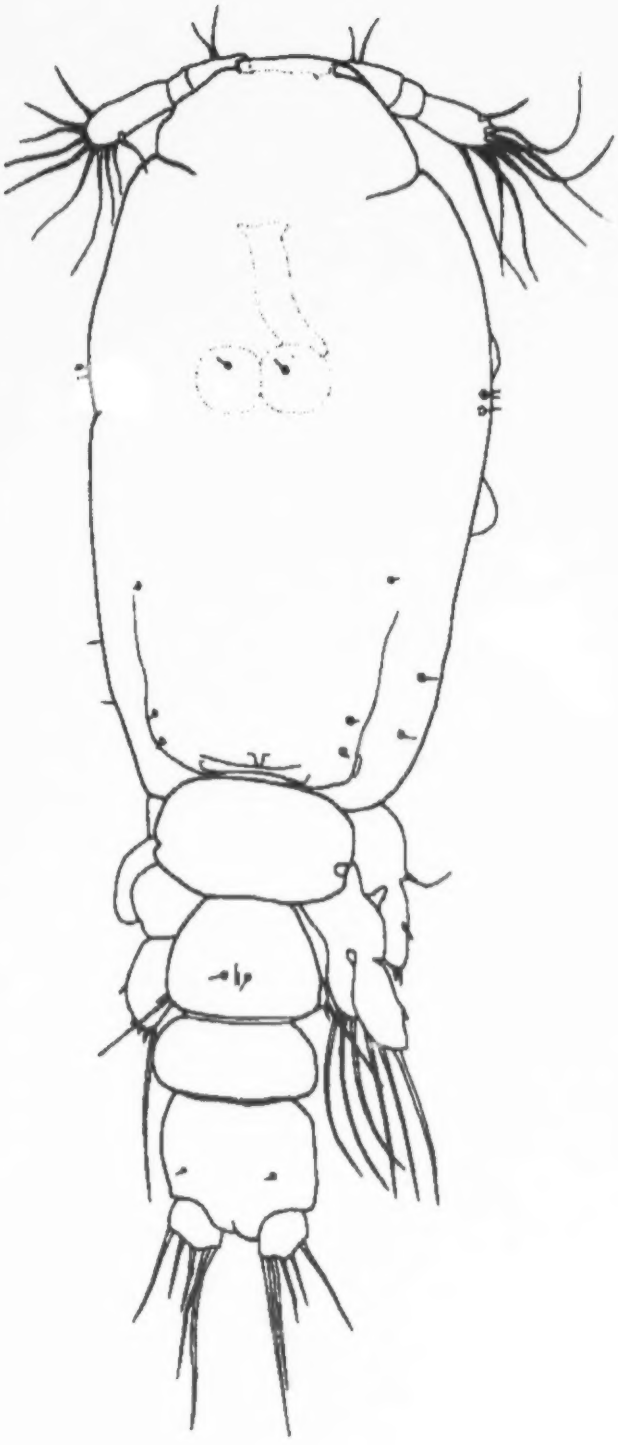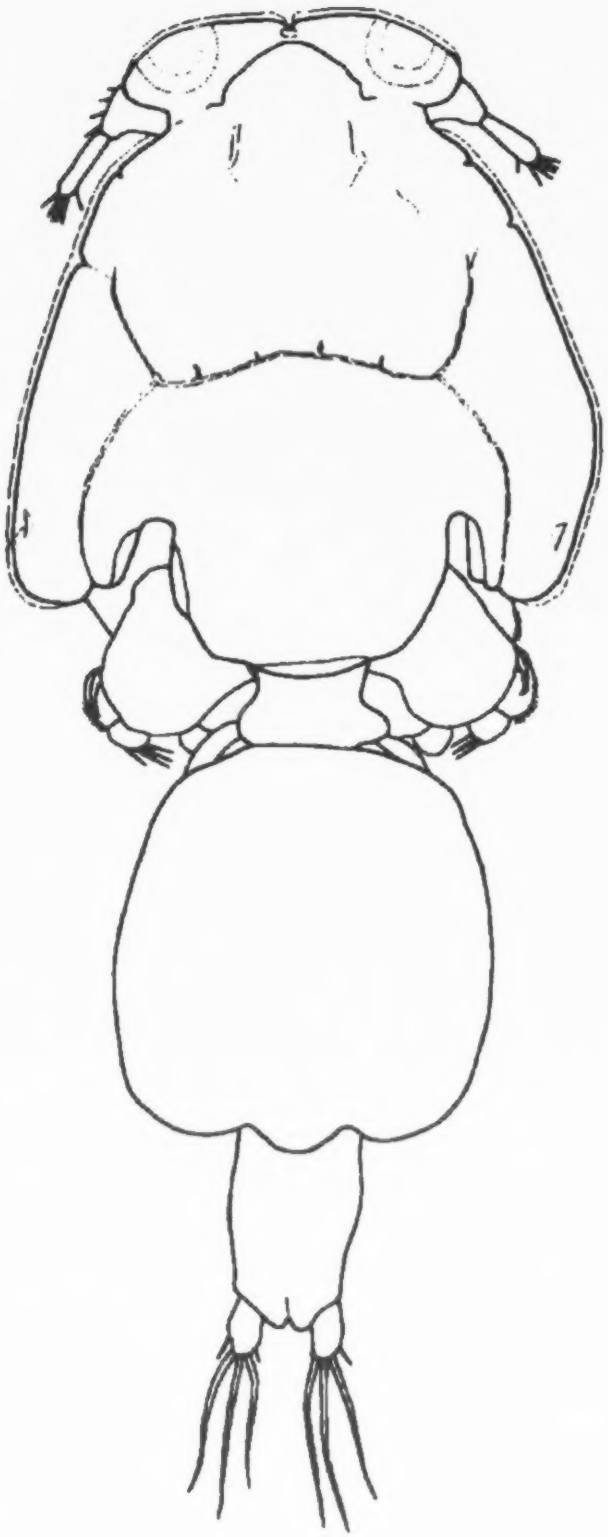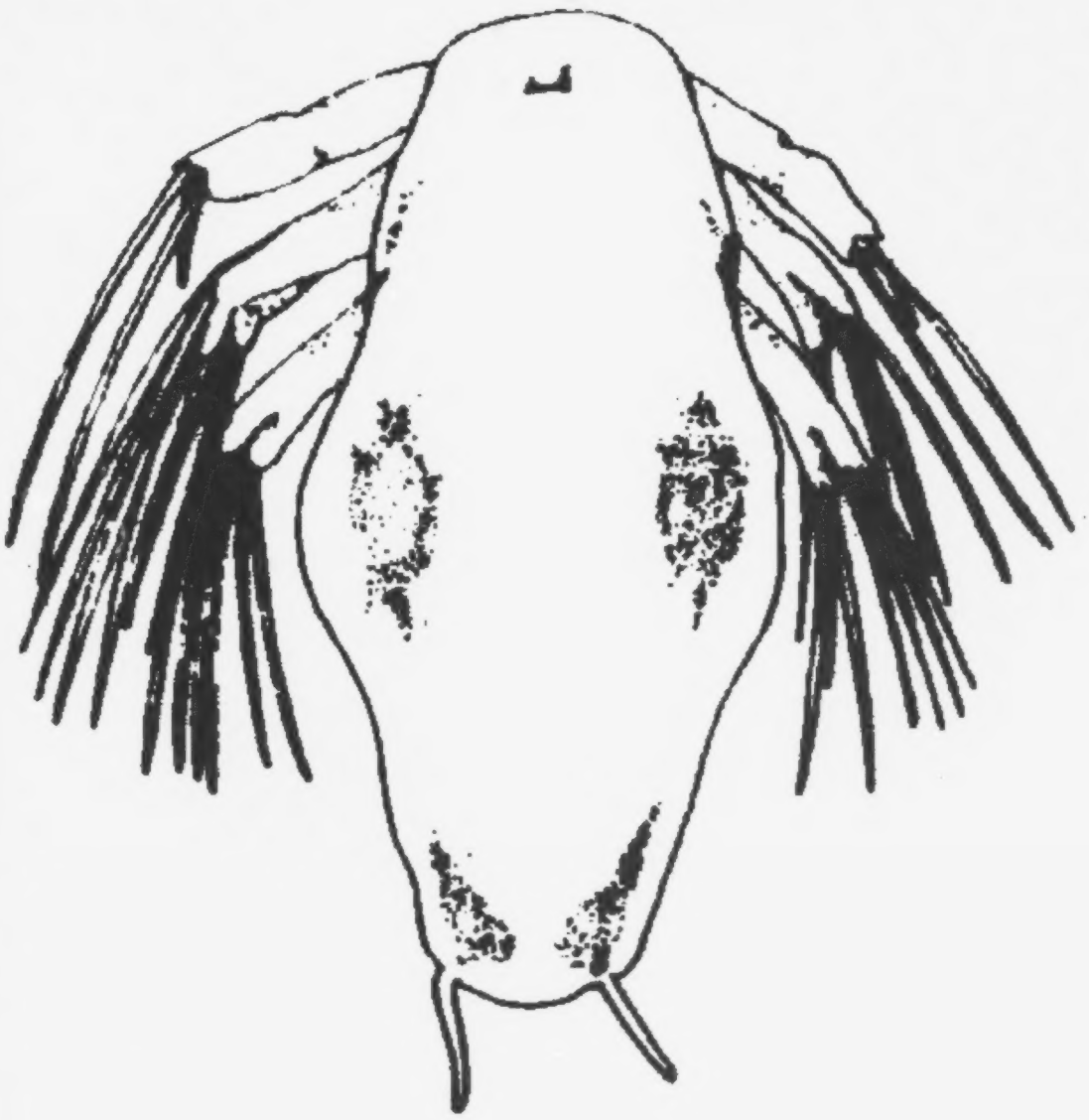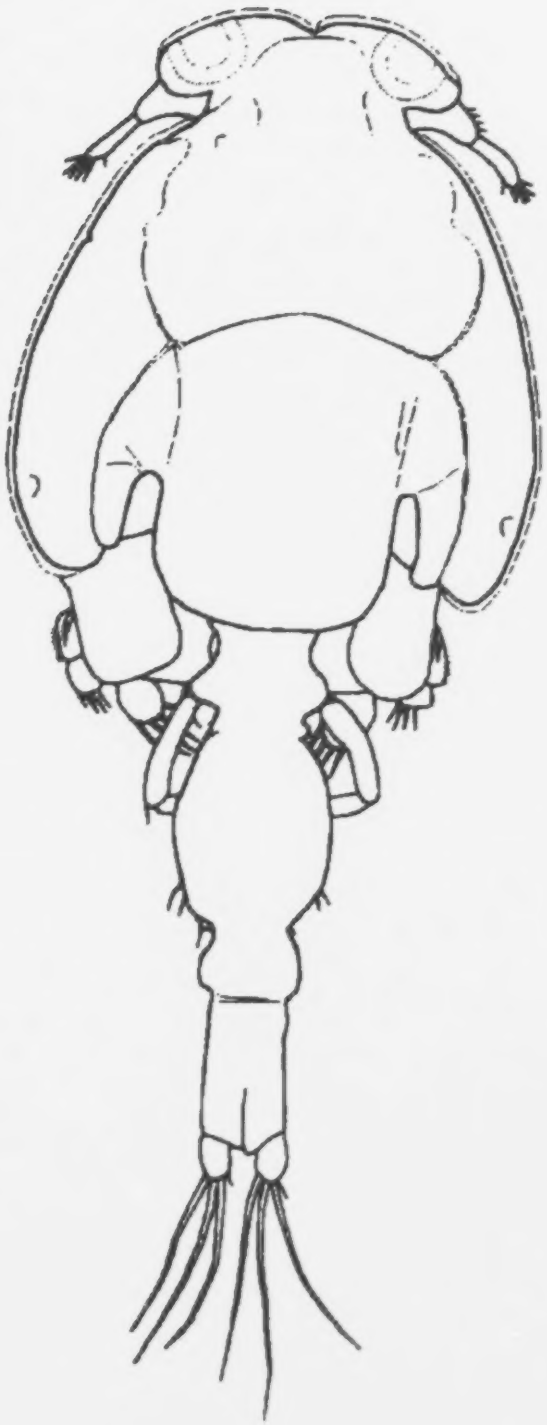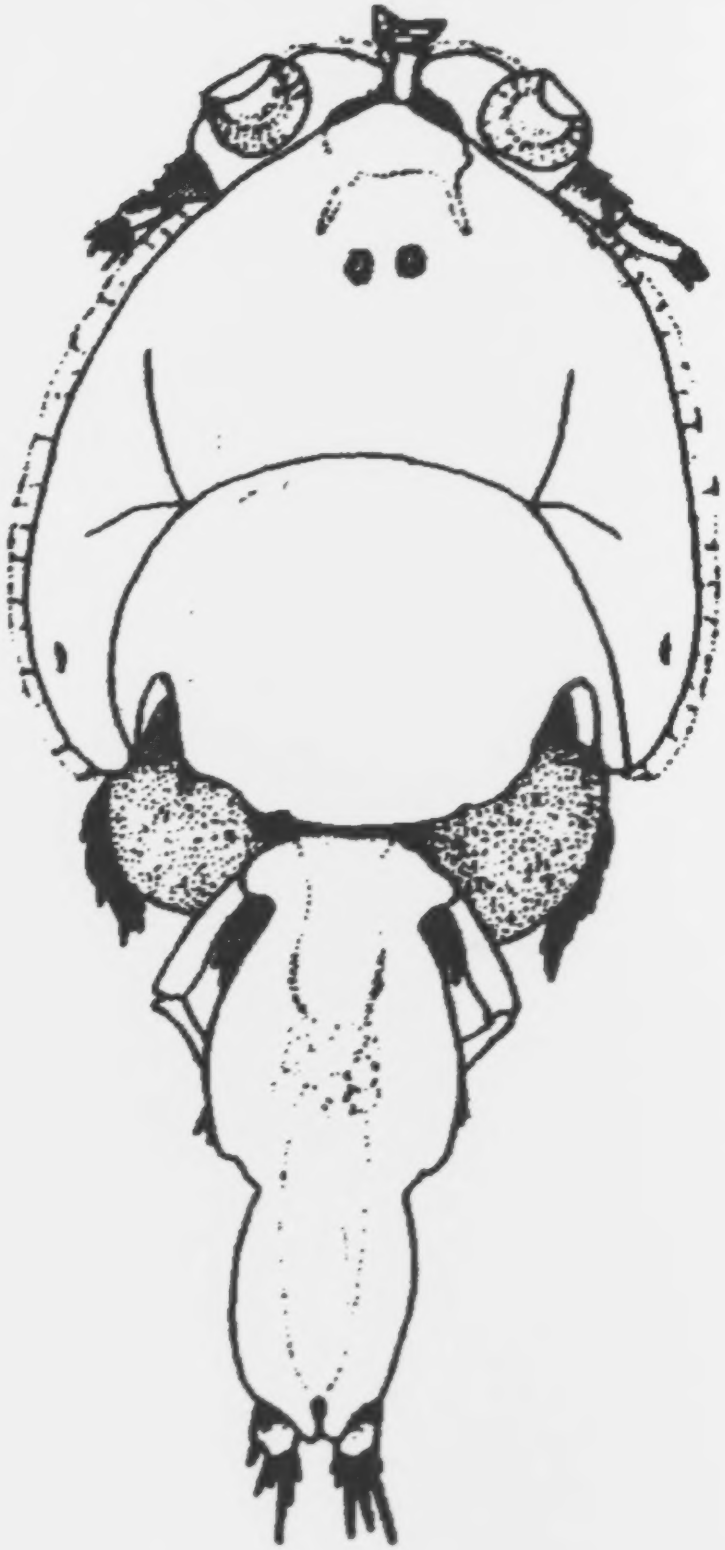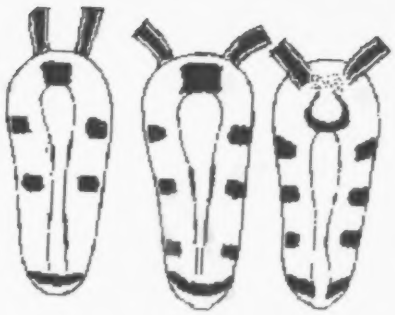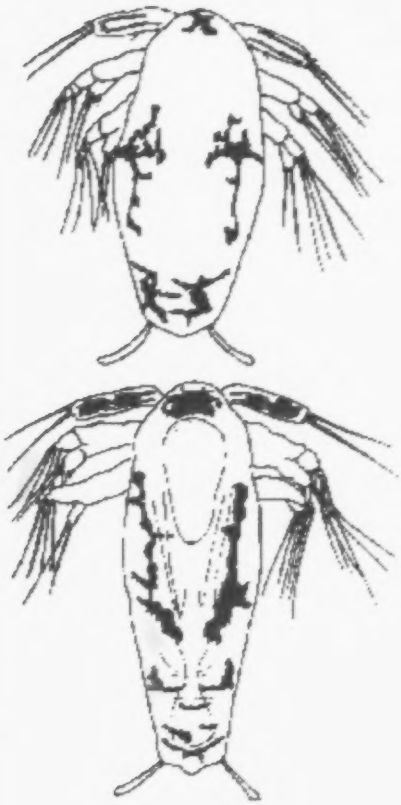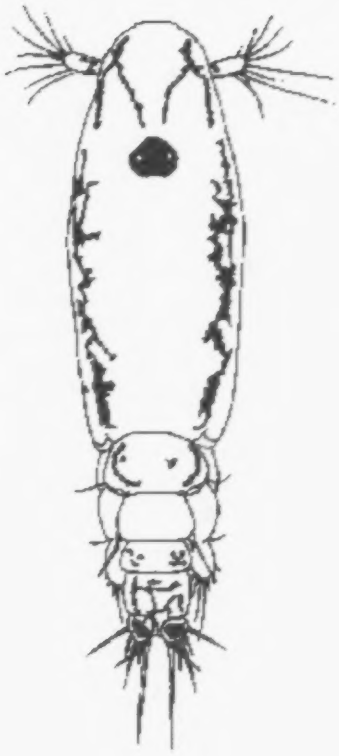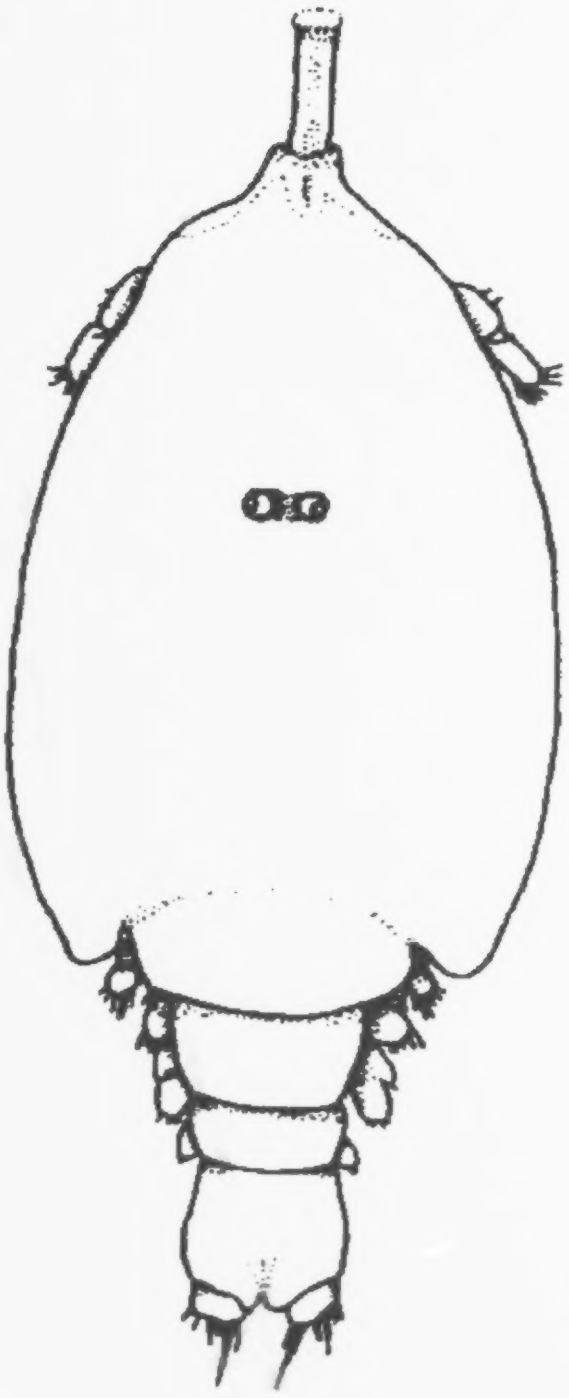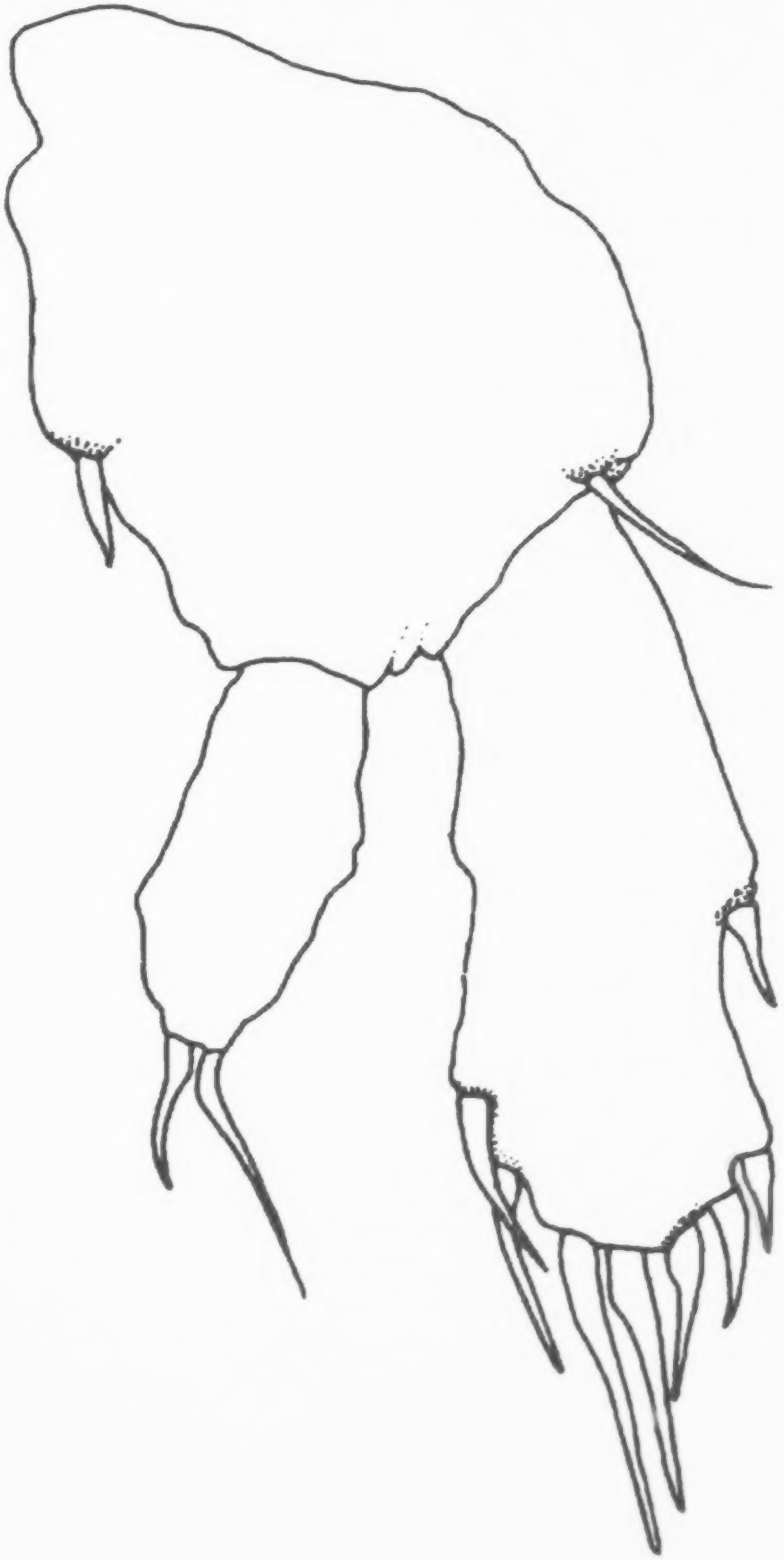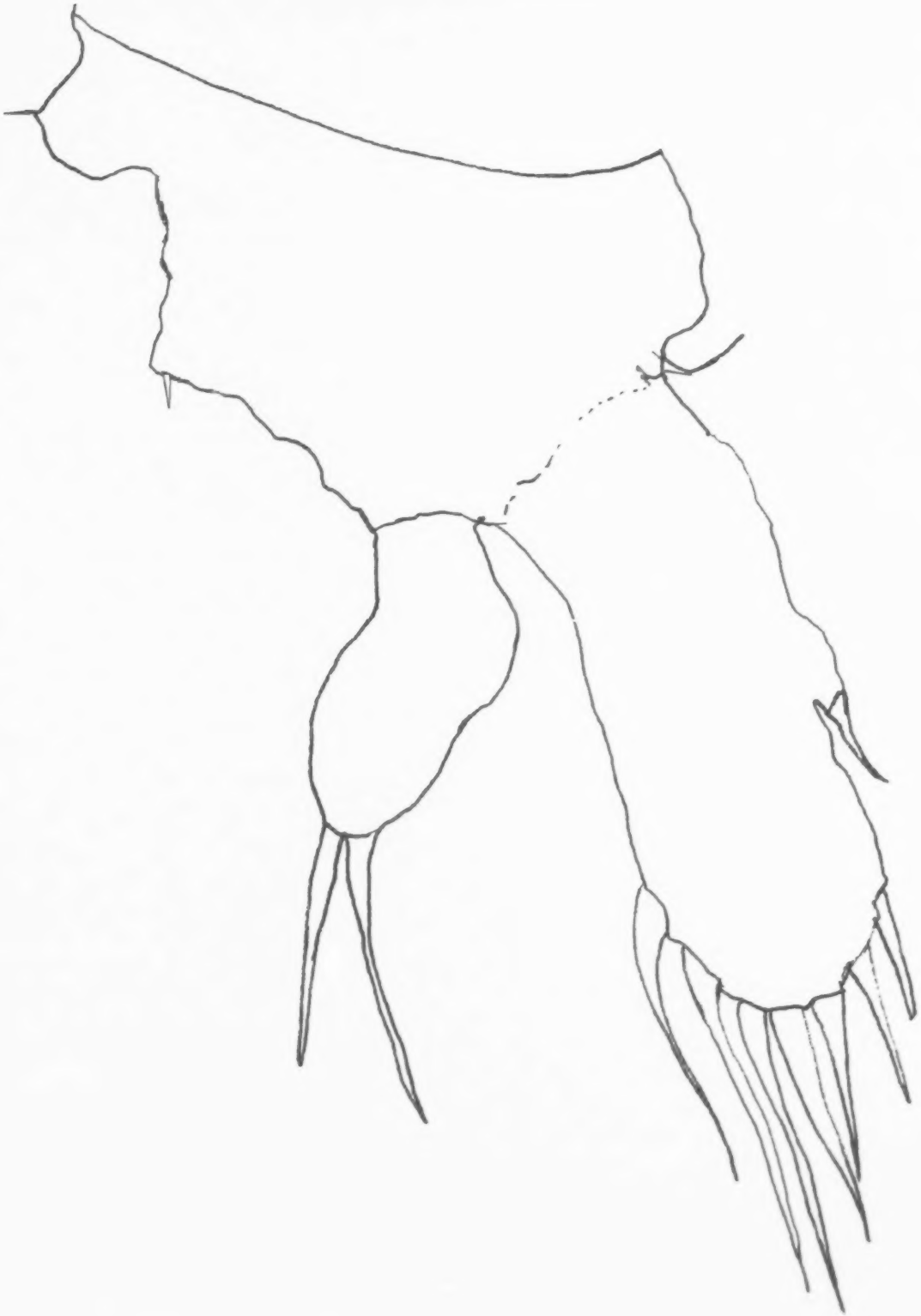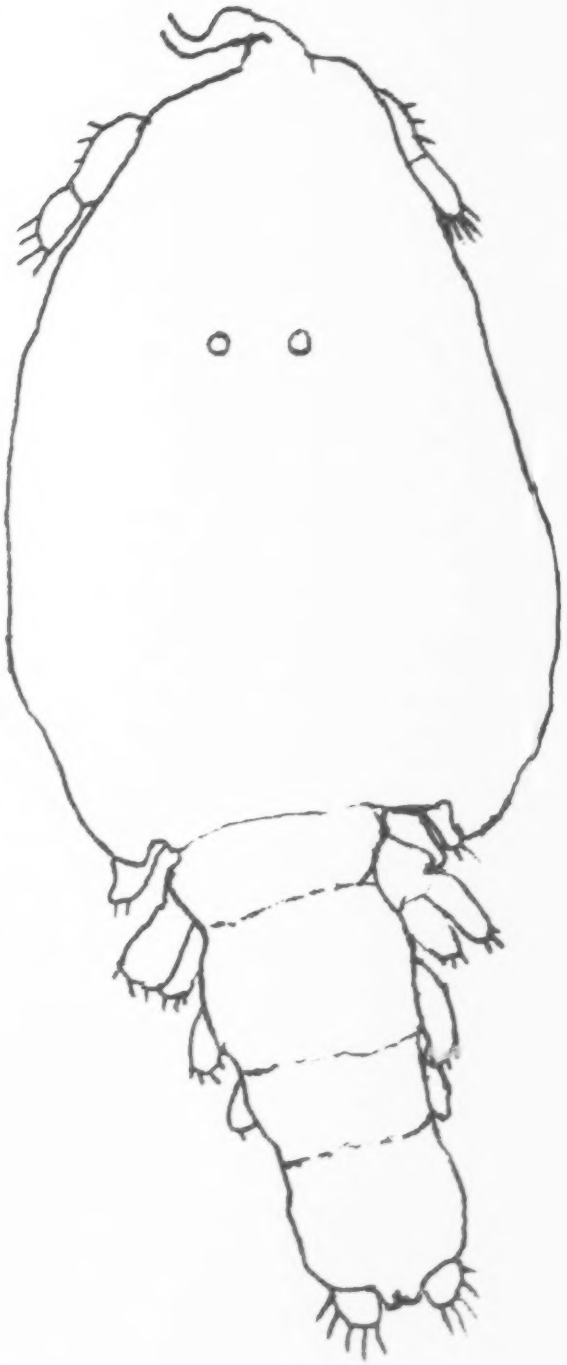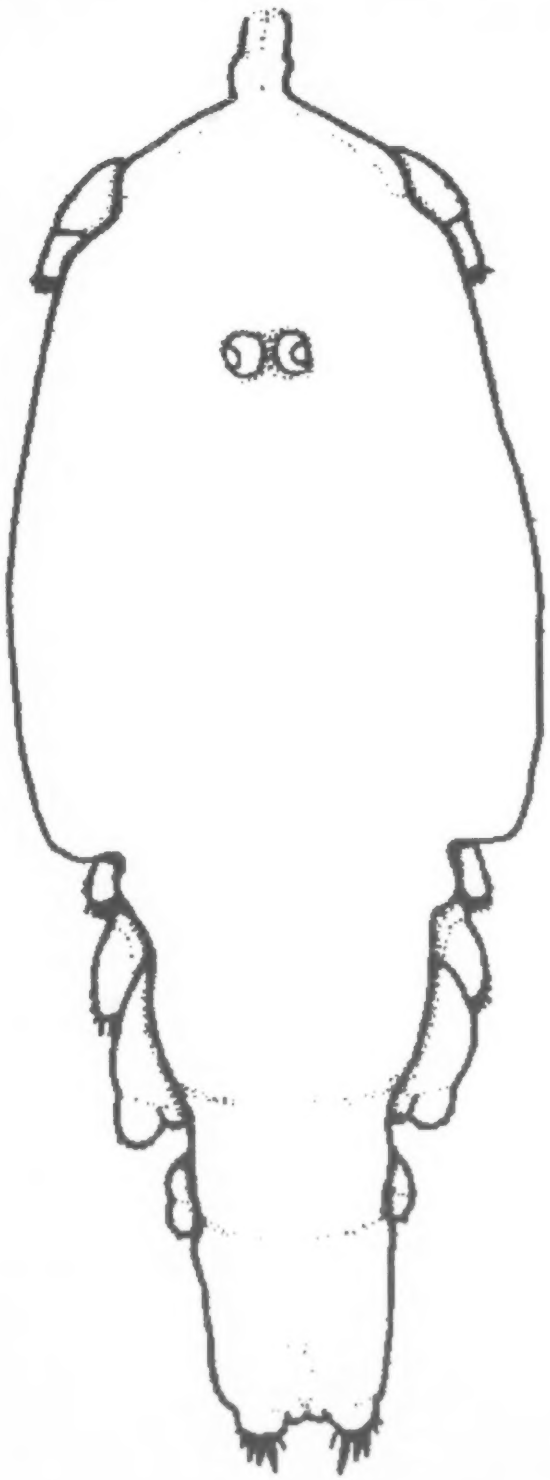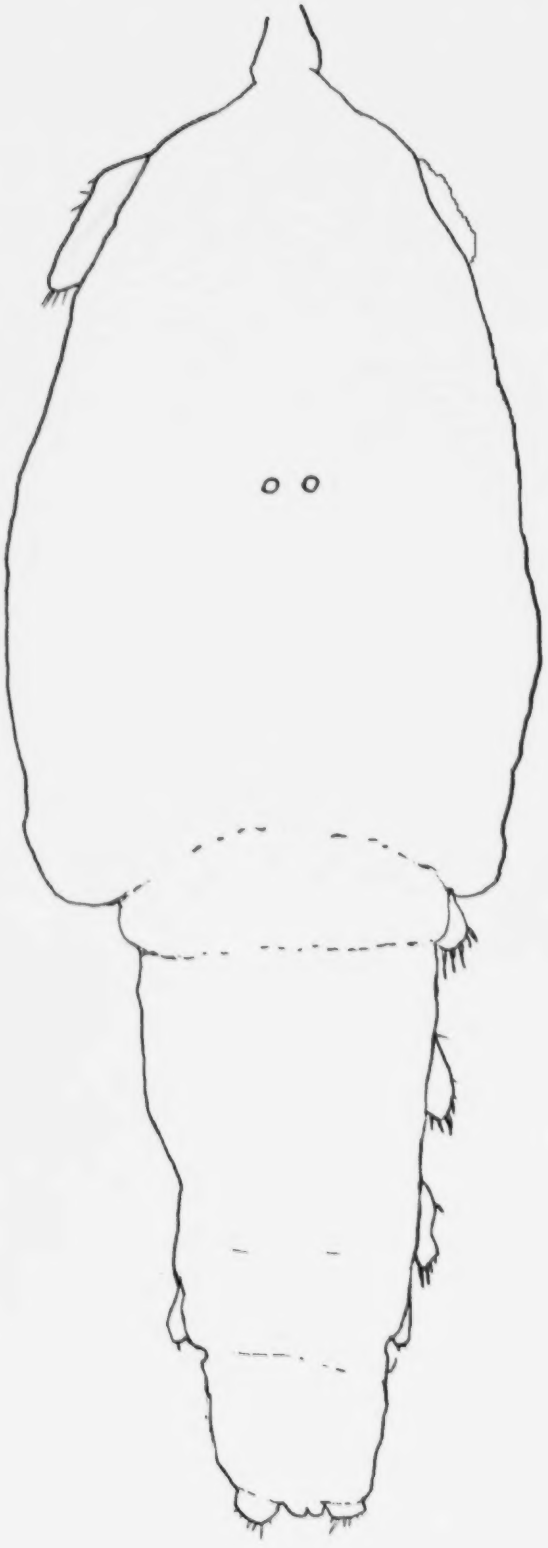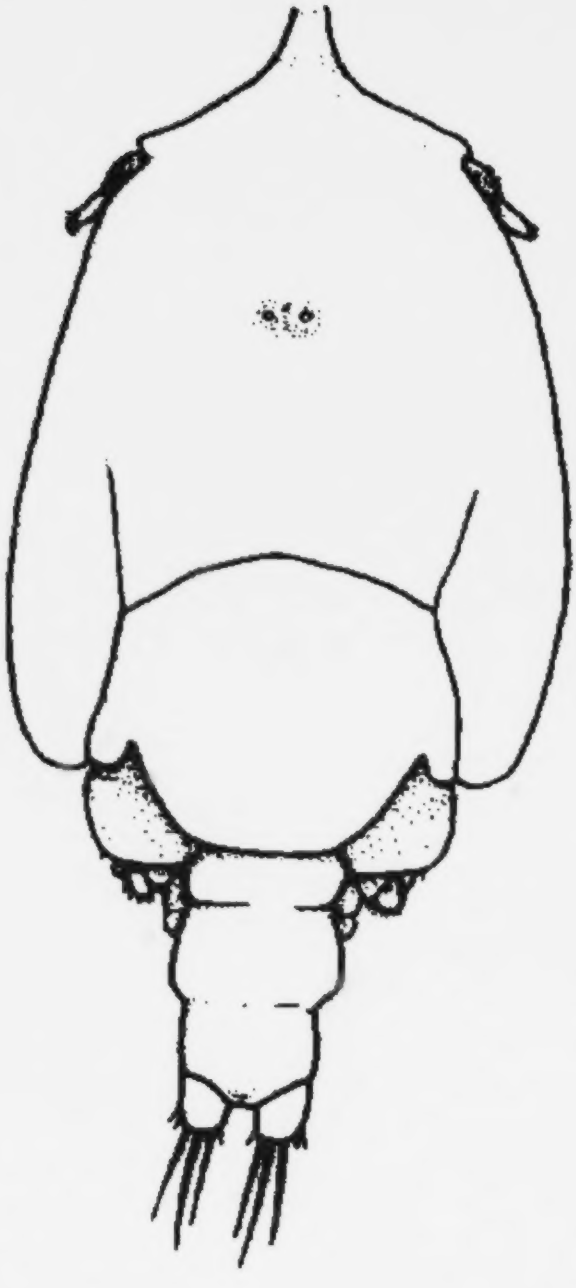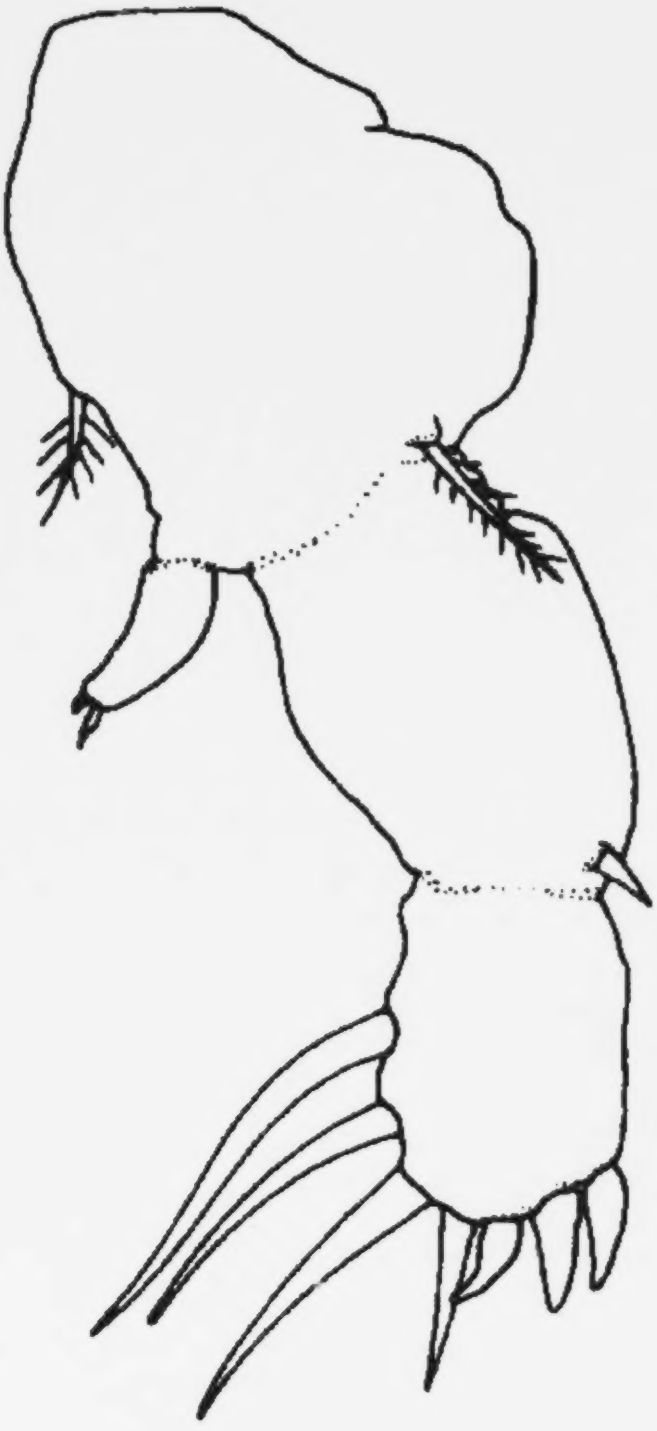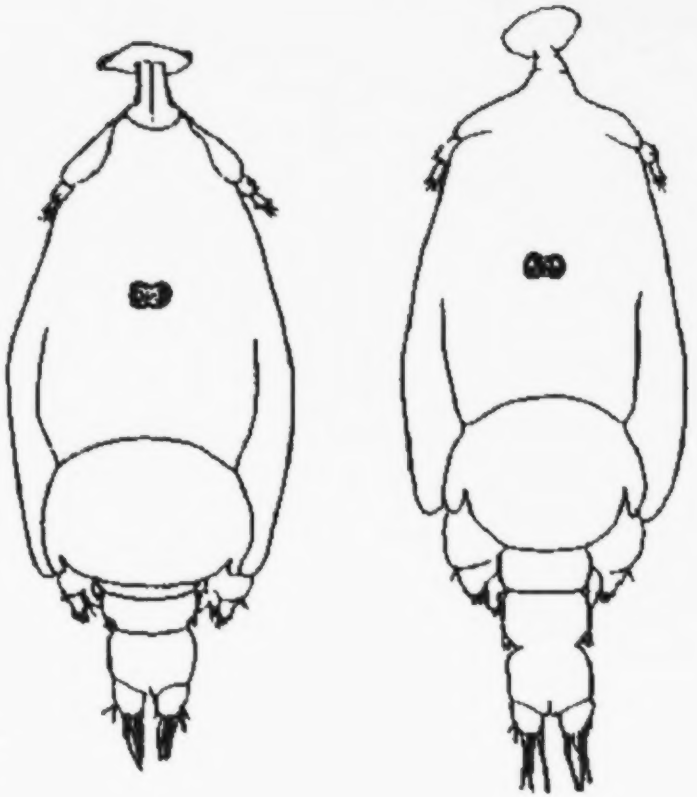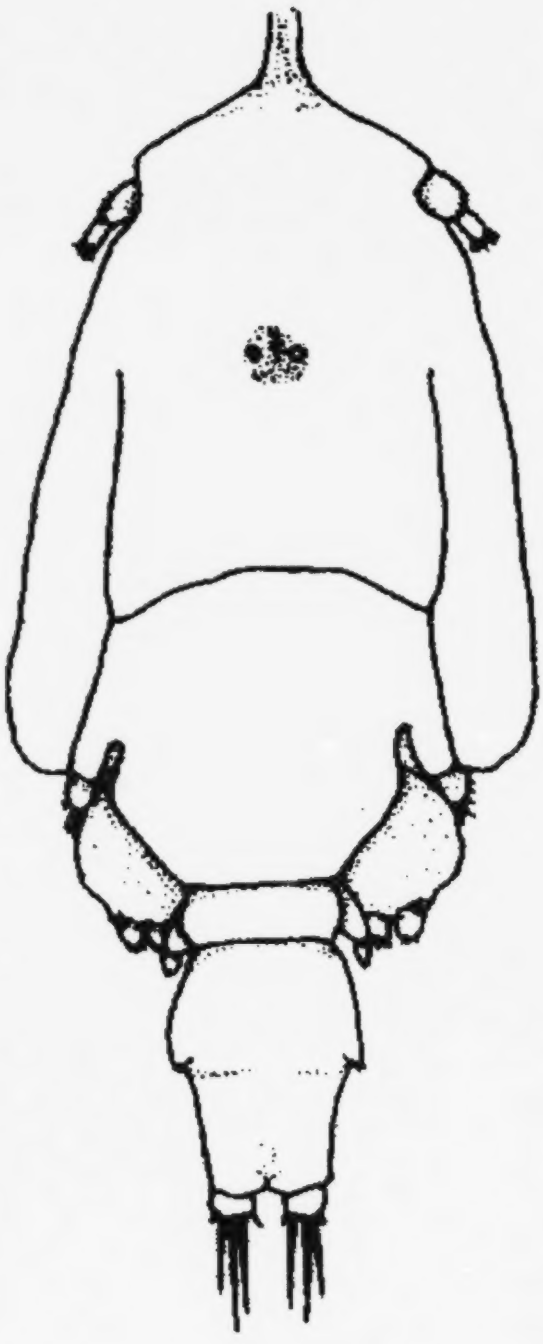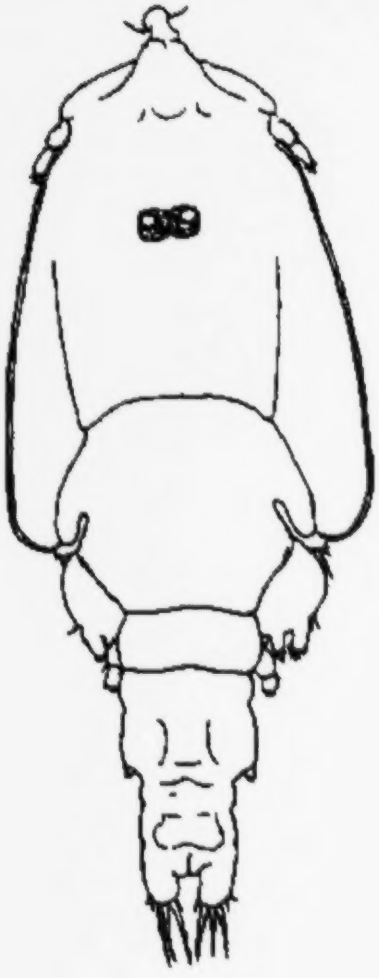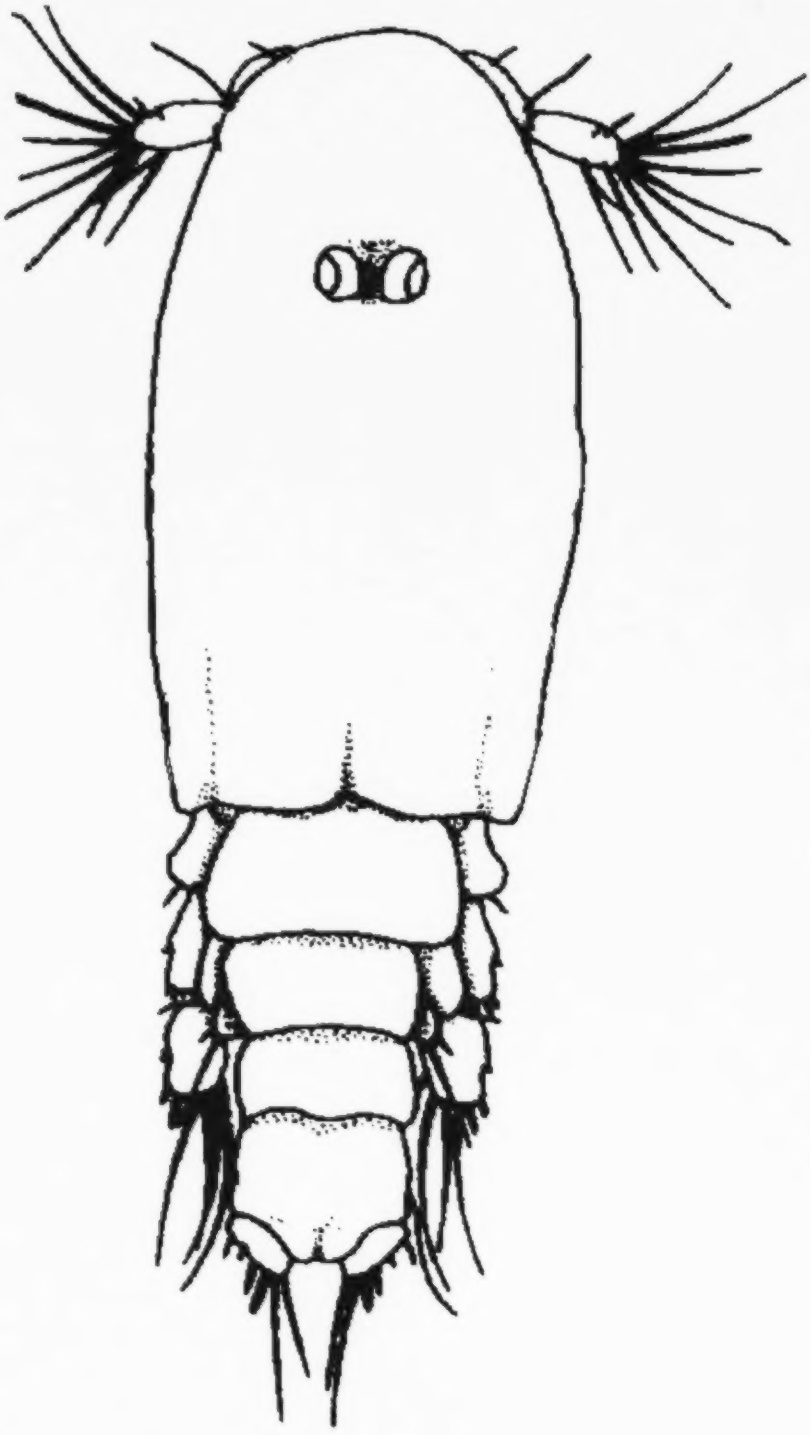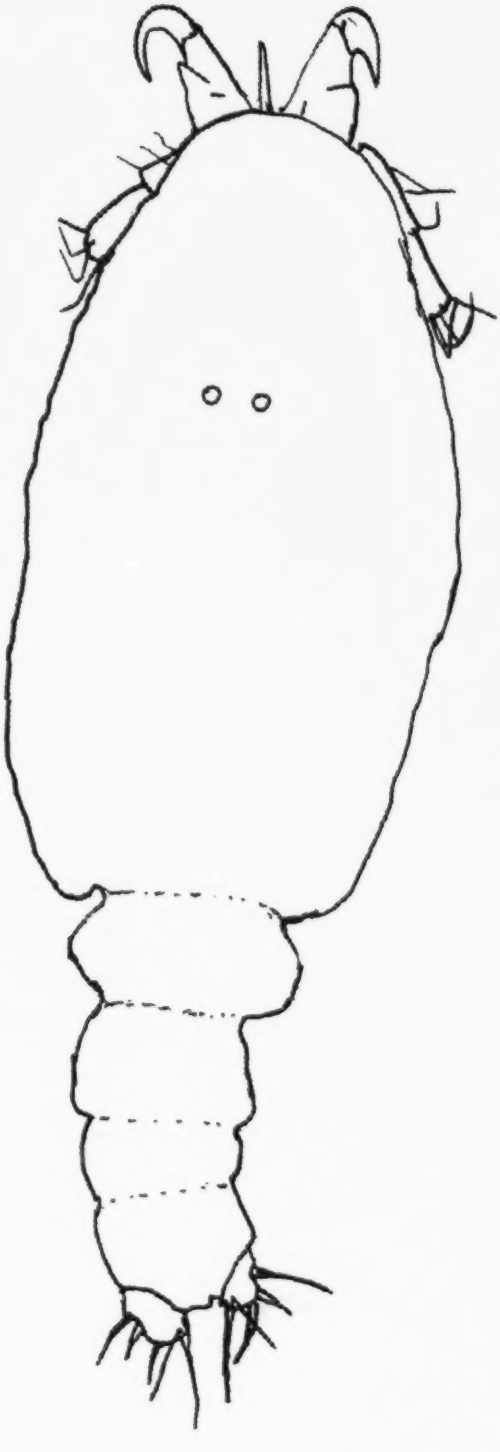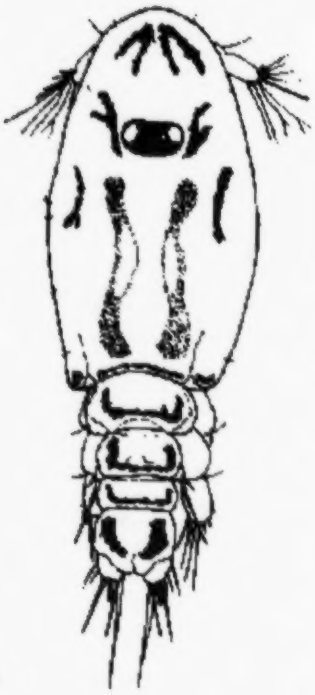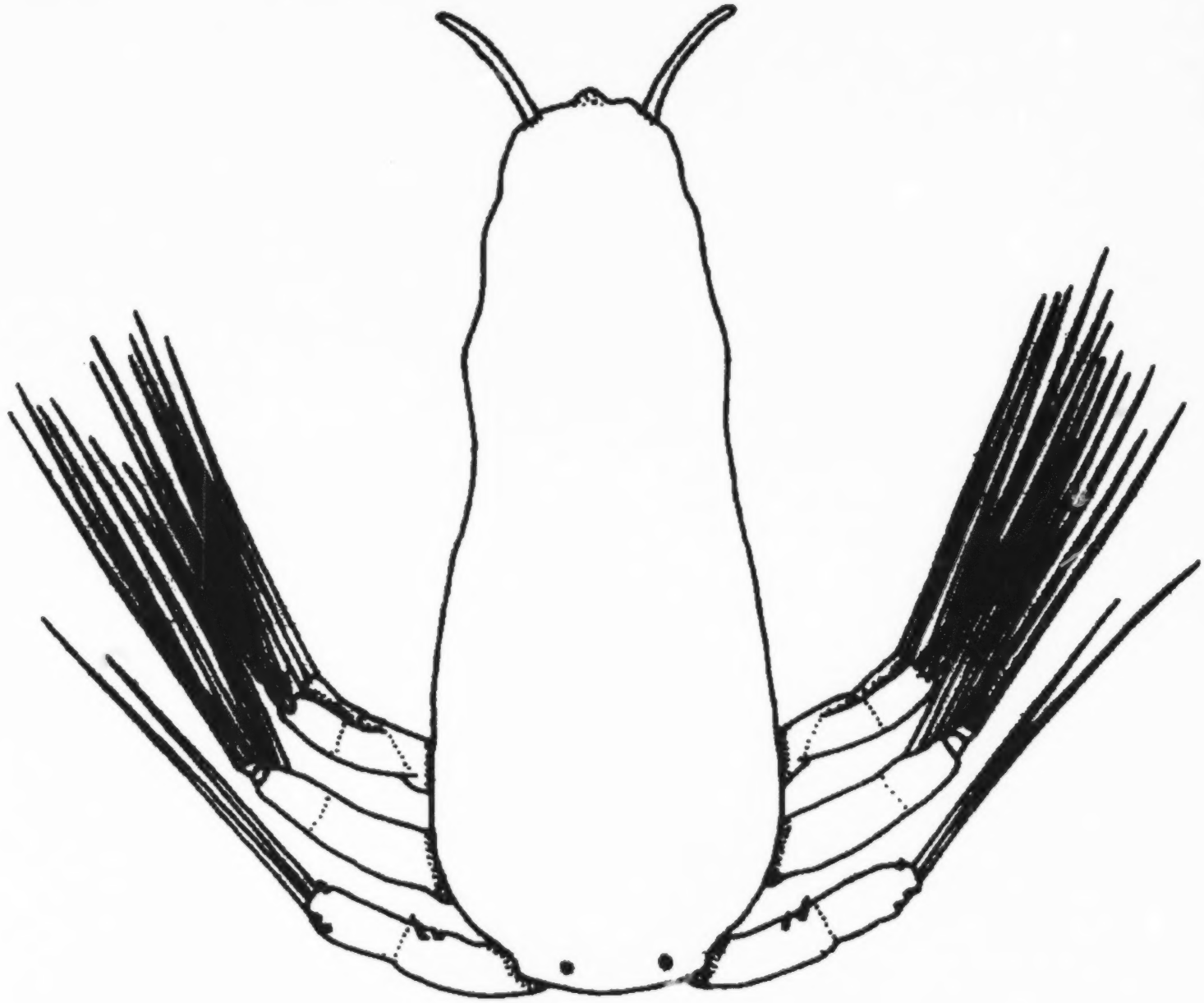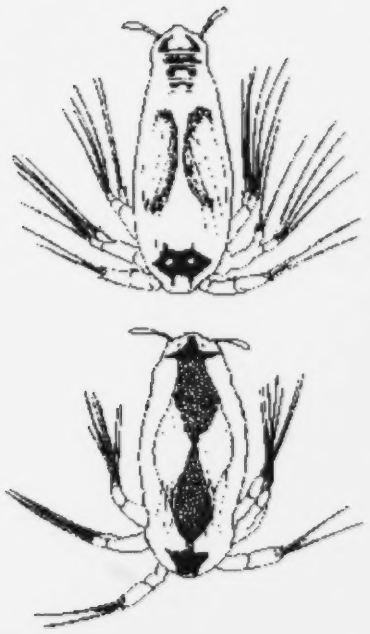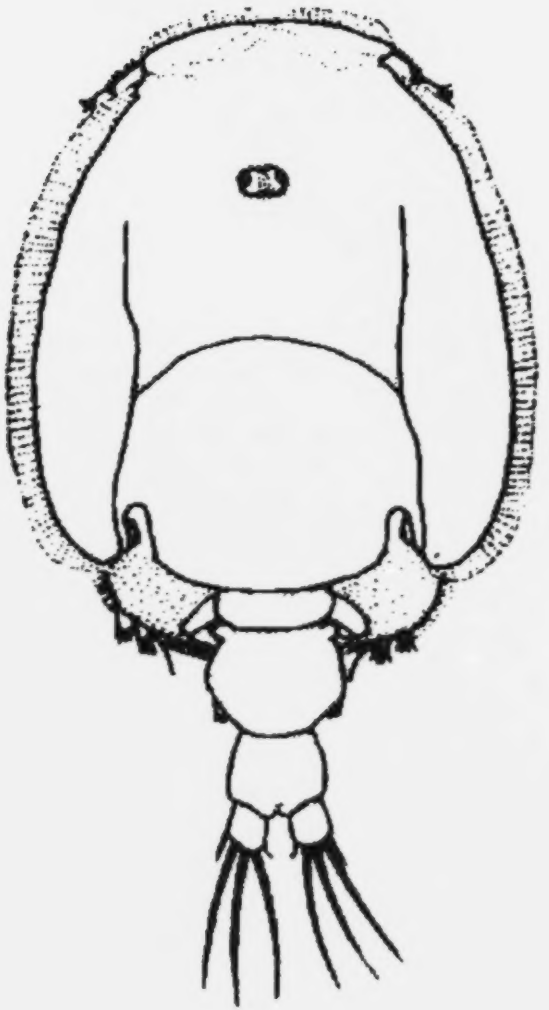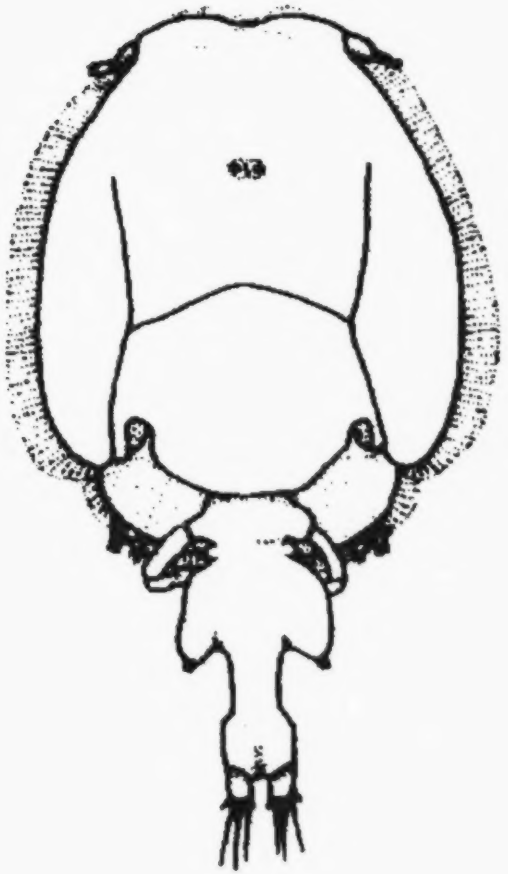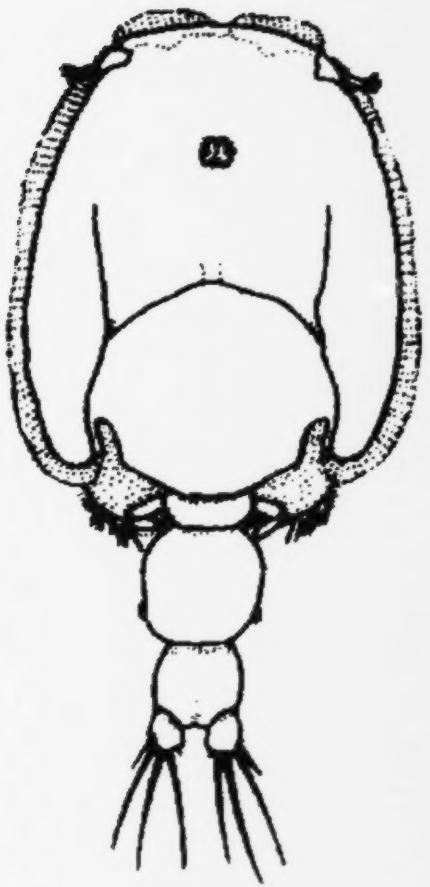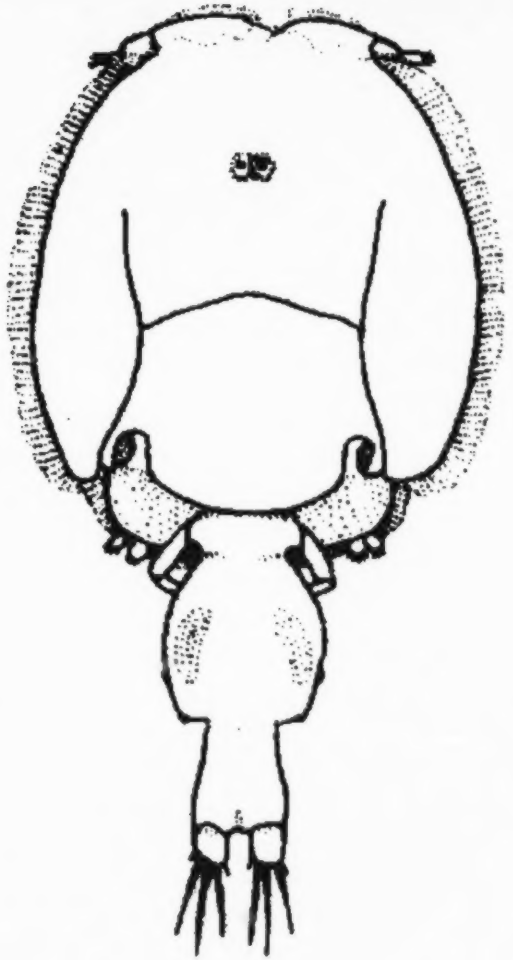
Eucalanus
Rhincalanus
Euchaeta
Centropages